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# NUCLEAR SCIENCE ABSTRACTS

## CHEMISTRY

### Analytical Chemistry

*Refer also to abstract 14443.*

13726 (LA-4092) HEALTH AND SAFETY MANUAL OF THE ANALYTICAL CHEMISTRY GROUP. Ashley, William H.; Henicksman, Arthur L.; Zerwekh, Al; Metz, Charles F. (Los Alamos Scientific Lab., N. Mex.). Aug 1969. Contract W-7405-eng-36. 30p. Dep. CFSTI.

Topics covered include: emergency action, heart-lung resuscitation, general safety, safety in handling hazardous materials, shop safety, electrical safety, fire safety, and safety in handling fissionable materials. (M.C.G.)

#### Chemical and Spectral Procedures

*Refer also to abstracts 14111 and 14291.*

13727 (LA-4160-tr) NONDESTRUCTIVE METHOD FOR THE DETERMINATION OF THE RATIO O/U IN SINTERED PELLETS. Ferro, C.; Moretti, S.; Patimo, C. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). Translated for Los Alamos Scientific Lab., N. Mex., from report RT/ING-(67)7. 7p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 42593.

13728 (MLM-1609) MOUND LABORATORY CHEMISTRY AND PHYSICS PROGRESS REPORT: JULY-SEPTEMBER 1969. (Mound Lab., Miamisburg, Ohio). 9 Feb 1970. Contract AT-(33-1)-Gen-53. 47p. Dep. CFSTI.

The $\alpha$ branching ratio of $^{227}Ac$ was determined by two independent methods. The intermediate means from the two methods were in good agreement: (1.3802 ± 0.0069)% and (1.3799 ± 0.0045)%. The weighted grand mean from 12 determinations was (1.3800 ± 0.0036)%. A computational technique was developed and tested which is believed to be useful as a nondestructive analytical tool for the determination of $^{227}Ac$ by $\alpha$ spectrometry in the presence of interfering decay products. A new method of preparing fluorite-type oxide hydrides of gadolinium was developed. The compounds can be prepared by dissolving gadolinium metal in warm, aqueous sodium hypochlorite or in acids such as acetic, propionic or propiolic. Some observations on the chemical stability of these compounds are presented. New facilities for the recovery of uranium-234 from waste plutonium-238 anion exchange raffinates are in operation. The process includes extraction of the uranium with trioctylphosphine oxide, stripping from the organic phase, and purification by anion exchange. Minor problems were encountered in the start-up, the main one being that of analysis of various intermediate process solutions. A total of 3.23 g of uranium-234 has been recovered and purified in the new facilities. In regard to thorium-229 recovery analytical work on the uranium-233 raffinate was concluded and the presence of large quantities of thorium-232 was confirmed. Because of this result, plans for future recovery of the thorium content are indefinite. Several different analytical techniques were used to determine the total boron content and the impurity levels of a number of boron samples. Good agreement was obtained for impurity determinations between atomic absorption spectrophotometry and emission spectroscopy. A spectrophotometric technique is being tested for analysis of the water content of 2-ethyl-1-hexanol. A spectrophotometric method using Arsenazo-III for determining trace quantities of thorium in samples containing uranium is being developed. Investigation revealed that up to four times as much uranium as thorium in a sample did not considerably affect the thorium analysis. In addition, small amounts of nitric acid and aluminum caused little interference. X-ray diffraction techniques are being used to determine the lattice parameters and crystal structure of calcium tellurate. Film data and corrected diffractometer data were used to compute three-dimensional Patterson functions for the compound. The compound can be considered isomorphous with calcium uranate because of the similarity between the diffraction diagrams of the two materials. (J.G.B.)

13729 (NIM-450) SPECTROGRAPHIC DETERMINATION OF ALKALI METALS AND ALKALINE EARTHS IN URANIUM OXIDE. Russell, Gerda M.; Watson, A. E.; Steele, T. W. (National Inst. for Metallurgy, Johannesburg (South Africa)). 14 Aug 1968. 5p. Dep. CFSTI (U. S. Sales Only).

The uranium oxide is mixed with a carrier of lead fluoride and silver chloride and packed into electrodes. Spectrograms are taken in a controlled atmosphere of 20% oxygen and 80% argon and comparisons made with standards. Ba, Ca, Sr, Cs, K, Li, Na, and Rb were determined. (M.C.G.)

13730 (NIM-451) DETERMINATION OF THORIUM IN BADDELEYITE AND CARBONATITE ORES AND IN THE SOLUTIONS RESULTING FROM LEACHING OF THESE ORES. Cook, E. B. T.; Russell, B. G. (National Inst. for Metallurgy, Johannesburg (South Africa)). 26 Aug 1968. 30p. Dep. CFSTI (U. S. Sales Only).

The sample is decomposed by fusion with sodium peroxide and leached in water. After most of the silica and alumina are removed by filtration, the hydroxide precipitate is dissolved in hydrofluoric acid, and thorium fluoride is precipitated. Calcium or lanthanum is added as a carrier. The fluorides are separated by filtration and decomposed with perchloric acid. Thorium is determined spectrophotometrically on an aliquot portion of this solution with Arsenazo III as the colorimetric reagent. Where lanthanide elements exceed thorium by a ratio of more than 1 to 1, thorium is separated by extraction of its acetylacetonate into benzene, and subsequently by back-extraction into dilute hydrochloric acid. This step is conducted on the solution obtained after the decomposition of the fluorides. The coefficient of variation is 1.2% for the shorter method and 2.2% for the longer. A similar, slightly modified procedure is used for the determination of thorium in leach solutions. (auth)

13731 (NIM-485) GRAVIMETRIC DETERMINATION, USING NITRON, OF NITRATES IN URANIUM COMPOUNDS. Steele, T. W.; Ziesing, Daphene A.; Stoch, H. (National Inst. for Metallurgy, Johannesburg (South Africa)). 14 Apr 1969. 4p. Dep. CFSTI (U. S. Sales Only).

The nitrate is precipitated from dilute acid solutions using Nitron and the precipitate is filtered, dried, and weighed. The method is applicable to solid or liquid uranium samples containing more than 2% nitrate and free of anions that form insoluble salts with Nitron. (M.C.G.)

13732 (ORNL-4466) ANALYTICAL CHEMISTRY DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING OCTOBER 31, 1969. Raaen, Helen P. (comp. and ed.) (Oak Ridge National Lab., Tenn.). Jan 1970. Contract W-7405-eng-26. 187p. Dep. CFSTI.

Ten sections are included; an abstract was prepared for each. Separate key word and author indexes are included. (P.C.H.)

*For abstracts of individual sections see: 13733–13740, 13777, and 13805.*

**13733** (ORNL–4466, pp 1-11) ANALYTICAL INSTRUMENTATION. Fisher, D. J.; Stelzner, R. W. (Oak Ridge National Lab., Tenn.).

Developments in instruments for use in analytical chemistry are described. These include such instruments as: polarographic mercury-flow-rate controller; coulometric titrator; low-frequency dual-set-point voltage comparator; sweep-control module for NMR measurements by use of the signal-averaging technique and NMR; modified GeMSAEC fast analyzer; cell design for minimizing iR error in controlled-potential polarography of high-specific resistance solutions; model IX-A flame spectrophotometer; modification of a Leco rapid oxygen analyzer; analytical computer systems; and digital flame spectrophotometer. (P.C.H.)

**13734** (ORNL–4466, pp 12-25) ANALYTICAL METHODOLOGY. Schultz, W. D. (Oak Ridge National Lab., Tenn.).

Developments are reported for studies on: characterization of tobacco smoke and smoke condensates; gas chromatography; thin-layer chromatography; electroanalytical chemistry; research and support activities for Transuranium Research Laboratory; research and support activities for ecology; and decentralized preparation of abstracts for Nuclear Science Abstracts. (P.C.H.)

**13735** (ORNL–4466, pp 26-41) ANALYTICAL CHEMISTRY FOR REACTOR PROJECTS. Meyer, A. S.; Dale, J. M. (Oak Ridge National Lab., Tenn.).

Developments are reported for studies on: determination of oxide in MSRE slats by hydrofluorination; determination of total reducing power of MSRE salts; determination of U(III) in radioactive MSRE fuel by hydrogen reduction; voltammetric determination of U(IV)/U(III) ratios in MSRE fuel; computer-operated voltammetric determination of U(IV)/U(III) ratios; electroanalytical studies of the Ni/Ni(II) couple in molten fluorides; absorption spectra of 3d transition-metal ions in molten fluoride solutions; and spectrophotometric evidence for the existence of the superoxide ion in molten fluoride salts. (P.C.H.)

**13736** (ORNL–4466, pp 41-62) ANALYTICAL BIOCHEMISTRY. Goldstein, Gerald (Oak Ridge National Lab., Tenn.).

Developments are reported for studies on: statistically designed procedure for optimizing conditions for determination of a specific tRNA; determination of formyl-methionine-accepting tRNA; effects of organic compounds on aminoacylation of tRNA's; gel electrophoresis of RNA's; nucleoside and nucleotide analysis with the high-pressure uv analyzer; gas chromatography of nucleosides and nucleic acid bases; identification of urinary constituents collected from the uv analyzer; identification of urinary carbohydrates collected from the carbohydrate analyzer; automatic amino acid sequencing; gas chromatography of amino acid derivatives; and gas chromatographic analysis of NAS-NRC biochemicals. (P.C.H.)

**13737** (ORNL–4466, pp 89-93) METHODS DEVELOPMENT AND EVALUATION. Corbin, L. T.; Thomason, P. F.; Costanzo, D. A. (Oak Ridge National Lab., Tenn.).

A specially enclosed Cary 14 spectrophotometer has been used to determine valence states of plutonium to study the self-oxidation of $^{238}$Pu(IV) in concentrated solutions of nitric acid and to determine 1 to 2 μg of $^{243}$Am in the presence of a 100-fold excess of $^{244}$Cm. A liquid–liquid extraction method was developed to separate Ce(IV) from Bk(IV). Fluorination of MSRE fuel has proved to be a useful way to separate uranium from radioactive fission products and salts in the fuel. The decontaminated uranium then can be analyzed for isotopic distribution and also determined quantitatively by regular methods. Thermogravimetric equipment has been installed in a double glove box to permit the analysis of alpha-emitting materials. Three electrolysis cells were evaluated for the controlled-potential coulometric determination of uranium and plutonium; also, new solid-state controlled-potential coulometric titrators were evaluated in this study. An inverse polarographic method was developed to determine ppB concentrations of bismuth. New equipment for the analysis of proposed reactor fuels was obtained and is being evaluated. (auth)

**13738** (ORNL–4466, pp 93-5) MASS SPECTROSCOPY. Cameron, A. E. (Oak Ridge National Lab., Tenn.).

Developments in the performance and use of spark-source mass spectrometry for the analysis of α-emitting radioactive and transuranium elements and mass spectrometry for the analysis of organic samples predominantly from biologically oriented programs are discussed. (P.C.H.)

**13739** (ORNL–4466, pp 95-8) X-RAY AND OPTICAL SPECTROSCOPY. Feldman, Cyrus (Oak Ridge National Lab., Tenn.).

Developments are reported for studies on: x-ray spectroscopy; chemical preconcentration of trace elements in bone ash — removal of phosphate from bone ash solutions; determination of moisture and fat contents of bone; determination of traces of Bi and rare earth elements in MSRE fuel; and dissolution of Hastelloy N and $GeO_2$. (P.C.H.)

**13740** (ORNL–4466, pp 99-101) OPTICAL AND ELECTRON MICROSCOPY. Willmarth, T. E.; Hulett, L. D.; Harmon, T. G. (Oak Ridge National Lab., Tenn.).

Developments are reported for studies on: electron microscopy of radioactive materials; evaluation of electron spectroscopy for chemical analysis (ESCA); and preparation of metallographic specimens for transmission electron microscopy. (P.C.H.)

**13741** DETERMINATION OF U(III) IN AQUEOUS SULFURIC ACID SOLUTION. Duflo-Plissonnier, M. (Institut de Physique Nucleaire, Paris). Radiochem. Radioanal. Lett.; 2: 321-6 (31 Dec 1969). (In French).

The instantaneous oxidation of U(III) by an excess of U(VI) is used for the titration of U(III), to test Beer's Law at 520 nm and to determine the molecular extinction coefficient of U(III): $\epsilon = 180 \pm 5\ M^{-1}\ cm^{-1}$. (auth)

**13742** SEPARATION AND DETERMINATION OF OSMIUM AND RUTHENIUM. Moseley, Harry Edward. Baton Rouge, La.; Louisiana State Univ. (1969). 44p.

Thesis.

Methods for the separation and determination of Os and Ru were studied. A technique was devised whereby a mixture of the bromo complexes of the two metals can be resolved by solvent extraction. A 6 M HBr solution of the metals was extracted with 4-methyl-2-pentanone using a volume ratio of extractant to raffinate of 2:1. Osmium was quantitatively extracted from Ru after a 2 min equilliberation. The extraction was followed by means of the radioactive isotope tracers, $^{191}$Os and $^{103}$Ru. A spectrophotometric procedure was developed for the simultaneous determination of Os and Ru in the form of bromo complexes. It was found that a blue Ru thiourea complex could be formed in 6.7 M HBr solutions while the Os would be maintained as the hexabromosmate complex. Absorption maxima were at 620 mμ for the Ru complex and 446 mμ for the Os complex. Molar absorptivities for the Ru complex were $2.47 \times 10^3$ at 620 mμ and 763 at 446 mμ. For the Os complex molar absorptivities were 328 at 620 mμ and $6.81 \times 10^3$ at 446 mμ. The method is useable over the range of 5 to 30 ppM with an absolute error of ±1 ppM over the range. Other Pt metals interfere. A computer program for the Craig equation was written for use in making theoretical calculations of the separation efficiencies of a countercurrent extraction technique. (Disser. Abstr.)

**13743** NEPHELOMETRIC DETERMINATION OF SMALL AMOUNT OF TELLURIUM IN IRON AND STEEL. Maekawa, Shizuya; Kato, Kiyotoshi (Japan Steel Works Ltd., Hokkaido). Jap. Anal.; 18: 1334-9(Nov 1969). (In Japanese).

A simple and rapid method was established for determination of 0.0005 to 0.15% of Te in Fe and steel. The sample was taken up with $H_2SO_4$ in which metallic Te coagulated in aggregates and was removed from interfering elements. The separated Te was dissolved in $HNO_3$ and $HClO_4$. The solution was evaporated to vigorous fumes of $HClO_4$, cooled, and to it was added 10 ml of 6N HCl. After boiling for 2 to 3 min 5 ml of $SnCl_2$ solution (100 g of $SnCl_2$ dissolved in 100 ml of HCl with 2 g of Sn metal) and 2.0 ml of gum arabic solution (5%) were added successively. It was diluted exactly to 100 ml with water, and the turbidity of the solution is measured using a 370 mμ filter. The time required for an analysis was about 35 min. (NSA of Japan)

**13744** SPECTROPHOTOMETRIC STUDIES OF THORIUM AND YTTRIUM COMPLEXES WITH MOLYBDOPHOSPHORIC ACID. Madison, Bryan Lynn. Columbia, Mo.; Univ. of Missouri (1969). 128p.

Thesis.

Spectrophotometric methods for the determination of Th and Y were developed. Each method is based on the reduction of a molybdophosphoric acid complex to a complex with a blue hue. The effects of variables on the color-forming reactions are described, along with the optimum conditions for the formation of the blue hue. The complexes were characterized by mole ratio and continuous variations studies, and pyridine adducts of the complexes were isolated and characterized. The dependence of the systems on the presence of phosphate and the failure to show a definite interaction of molybdic acid with Th and Y indicate that simple

heteropoly acid formation is not occurring. It is therefore reasonable that the observed phenomena indicate a cation-anion interaction between the 11 : 1 molybdophosphoric acid anion and a phosphate complex of Th and Y. This gives additional support to the postulate that mixed heteropoly acids may not exist. The solvent extraction separation of Th with tri-n-octylphosphine oxide was studied. Thorium was determined in gross quantities of U compounds using a two-cycle solvent extraction procedure in the presence of EDTA. Uranium was shown to be preferentially extracted by TOPO from a 2 M nitrate solution. In addition, it was found that Y and the rare earths are extracted by TOPO. Elimination of this interference was accomplished by backwashing with a fresh 2 M nitrate wash solution. The methods developed are rapid, selective, and sensitive for the spectrophotometric determination of Th and Y. The systems obey Beer's law under all concentration ranges studied, and by proper choice of final concentration and absorbance cells, the methods can be applied over wide ranges of concentration. (Disser. Abstr.)

**13745** N-ACETYLSALICYLOYL-N-PHENYLHYDROXYLAMINE AS AN ANALYTICAL REAGENT. DETERMINATION OF NIOBIUM AND TANTALUM IN THE PRESENCE OF EACH OTHER. Savariar, C. P.; Joseph, Joy (Univ. of Calicut, Kerala, India). Talanta; 17: 45-50(Jan 1970).

N-Acetylsalicyloyl-N-phenylhydroxylamine is proposed for the separation of niobium(V) and tantalum(V) and their gravimetric determination. Niobium is precipitated at pH 5.5 to 6.5 by the reagent and the complex is weighed directly. Tantalum is precipitated from 1 to 2M hydrochloric acid solutions and the complex is ignited to tantalum pentoxide. The method is fairly selective. In the presence of thiocyanate the reagent forms an extractable complex with niobium. The reaction forms the basis of a selective and sensitive spectrophotometric determination of niobium. (auth) (UK)

**13746** SPECTROPHOTOMETRIC DETERMINATION OF NIOBIUM(V) WITH N-PROPYL 3,4,5-TRIHYDROXYBENZOATE. Jasim, Fadhil (Univ. of Baghdad). Talanta; 17: 103-5(Jan 1970).

The use of n-propyl 3,4,5-trihydroxybenzoate (PTB) for the spectrophotometric determination of niobium is investigated. PTB yields a yellowish-orange $ML_2$ chelate with Nb(V) at pH 6.1. The formation constant at pH 6.1 is about $10^{10}$. Beer's law is obeyed over the range 0 to 100 μg of Nb per ml. (auth) (UK)

**13747** USE OF 3-HYDROXYL-1,3-DIPHENYLTRIAZINE IN THE SPECTROPHOTOMETRIC DETERMINATION OF COPPER, PALLADIUM, IRON, COBALT, NICKEL, AND MOLYBDENUM. Das, B.; Shome, S. C. (Presidency Coll., Calcutta). Talanta; 17: 75-9(Jan 1970).

3-Hydroxy-1,3-diphenyltriazine (HDPTA) forms brightly coloured complexes with copper, palladium, iron, cobalt, and nickel ions, which are readily extractable in benzene. The deep yellow molybdenum complex is completely soluble in 60% ethanol. All the chelates have a definite absorption maximum between 398 and 422 nm, the reagent absorption being negligible above 415 nm. The molar composition of the chelates is $ML_2$, except for iron and cobalt tha form $ML_3$ complexes. Microquantities of these metals can be determined spectrophotometrically with HDPTA. (auth) (UK)

**13748** ASSAY OF $^{51}Cr$-DTPA AND $^{51}Cr$-EDTA BY PAPER CHROMATOGRAPHY. Jasz, A.; Pal, I. (Inst. of Isotopes, Budapest). J. Radioanal. Chem.; 3: 353-7(Nov 1969).

A method using ascending paper chromatography has been developed for determining radiochemical impurities, such as $^{51}Cr^{3+}$ and $^{51}CrO_4^{2-}$, in $^{51}Cr$-DTPA and $^{51}Cr$-EDTA ($^{51}CrY$) complexes. The chromate concentration of the sample to be checked is increased to about $5 \times 10^{-2}$ M by adding inactive chromate as a carrier, then the sample is applied onto a chromatographic paper strip (Whatman No. 1), and the impurities are precipitated at the start line with sodium hydroxide and lead acetate solution. The chromatogram is developed for 3 to 4 hours using a solvent mixture consisting of 25% ethanol and 75% bidistilled water, adjusted to pH = 8 with ammonia; the impurities remain fixed in the start line and thus separated from the chromium complexes, which migrate with an $R_f$-value of 0.8 to 0.9. (auth)

**13749** COMPARISON OF CERTAIN METHODS FOR QUANTITATIVE DETERMINATION OF ZIRCONIUM. Tselinskii, Yu. K.; Gorbenko, F. P.; Lapitskaya, E. V. Zh. Prikl. Khim.; 42: 2216-20(Oct 1969). (In Russian).

Comparative studies were made of gravimetric and volumetric methods for the determination of zirconium. Average errors were determined. (M.C.G.)

**13750** DETERMINATION OF ALUMINUM IN URANIUM ALLOYS USING CHROME AZUROL S. Mal'tseva, L. S.; Kubareva, L. V. (Inst. of Metallurgy, Moscow). Zavod. Lab.; 35: 1299-1301(1969). (In Russian).

The method is based on the photometric determination of aluminum using Chrome Azurol S after binding interfering elements in colorless complexes with ammonium tartrate or hydroxylamine hydrochloride. The method permits the determination of aluminum in amounts from 0.02 to several percent. (tr-auth)

**13751** POLAROGRAPHIC REDUCTION OF PROTACTINIUM(V) IN AQUEOUS SOLUTION AND IN ACETONITRILE. Schwochau, K.; Astheimer, L. (Kernforschungsanlage, Juelich, Ger.). J. Inorg. Nucl. Chem.; 32: 119-26(Jan 1970). (In German).

Only the first step at $E_{\frac{1}{2}} = -1.42$ V vs. S.C.E. in dc polarograms of aqueous fluoroprotactinate(V) solutions can be attributed to a clear electron transfer which corresponds to a reduction of Pa(V) → Pa(IV). Alternating current efficiencies of more than 80% suggest an almost complete reversibility of this electrode process. Therefore an ac polarographic determination of Pa is proposed. The second step at $E_{\frac{1}{2}} = -1.64$ V is mainly due to the catalytic evolution of hydrogen. In acetonitrile $PaCl_5$ is reduced at $E_{\frac{1}{2}} = -0.22$ V. By comparison with the heights of the steps of $NbCl_5$- and $TaCl_5$-polarograms a reduction of Pa(V) → Pa(III) can be supposed. (auth) (UK)

**13752** DETERMINATION OF GADOLINIUM IN SODIUM BORATE GLASSES. Reisfeld, Renata; Biron, Ehud (Hebrew Univ., Jerusalem). Talanta; 17: 105-8(Jan 1970).

A method for the determination of gadolinium in sodium borate glasses is described which utilizes the 312-nm fluorescence of gadolinium under 273-nm excitation. A linear dependence of fluorescence on concentration is found for the concentration range 10 to 20,000 ppM. Quenching of gadolinium fluorescence by samarium is examined. (auth) (UK)

**13753** ANION-EXCHANGE SEPARATION AND SPECTROPHOTOMETRIC DETERMINATION OF MOLYBDENUM AND TUNGSTEN IN SILICATE ROCKS. Kawabuchi, Kazuaki; Kuroda, Rokuro (Univ. of Chiba, Japan). Talanta; 17: 67-73(Jan 1970).

A combined ion-exchange spectrophotometric method has been developed for the determination of molybdenum and tungsten in silicate rocks. After the decomposition of samples with a mixture of sulphuric, nitric, and hydrofluoric acids, traces of molybdenum and tungsten are separated from other elements by anion exchange in acid sulphate media containing hydrogen peroxide. The adsorbed molybdenum and tungsten can easily be stripped from the column by elution with sodium hydroxide–sodium chloride solution. The adsorption and desorption steps provide selective concentration of molybdenum and tungsten, allowing the simultaneous spectrophotometric determination of the two metals with dithiol. Results on the quantitative determination of molybdenum and tungsten in the U. S. Geological Survey standard samples are included. (auth) (UK)

**13754** APPLICATIONS OF ATOMIC ABSORPTION SPECTROPHOTOMETRY IN INDUSTRIAL PRODUCTION QUALITY CONTROL. Grison, J. (CEA, La Hague, France). Chim. Anal. (Paris); 51: 605-12(Dec 1969). (In French).

Atomic absorption spectrophotometry is used at the La Hague plant in order to reduce the costs of the manufacturing process quality control analyses. A special installation for the evacuation of effluents, both liquid and gaseous, allows its use on inactive or active solutions. It is thus possible to analyze diluted solutions of fission products and to determine the impurities present in uranium solutions. The technique of atomic absorption without flame makes it possible to analyze radioactive solutions directly on a shielded line or in a glove box, without previous dilution or separation. (J.G.B.)

**13755** MEASUREMENT OF THE COMPOSITION OF MIXED URANIUM–CERIUM OXIDES. Urbain, H. (CNRS, Villeurbanne, France); Veron, J. Chim. Anal. (Paris); 51: 613-18(Dec 1969). (In French).

The oxides involved correspond to the general formula $U_xCe_{1-x}O_{2+y}$. Chemical analysis reveals not only the atomic fractions x and 1 – x of the uranium and cerium elements by means of total measurement of these, but also the amount of excess (or shortage) of oxygen y, by measurement of the different valency states separately. (auth)

**13756** ATOMIC ABSORPTION SPECTROPHOTOMETRY INTERFERENCE. Rampon, H. (CEA, La Hague, France). Chim. Anal. (Paris); 51: 627-38(Dec 1969). (In French).

The application of atomic absorption spectrometry for analyses of various types of inactive and radioactive solutions has made it possible to cope with almost every type of interference. These consist of interactions due to adjustment parameters and flame emissions, spectral, ionization, matrix, and chemical interferences, the last two being the most important. There are simple means of detecting and studying them to attenuate or suppress them in most cases; the utilization of hot flames (nitrogen protox-

ide/acetylene), dilution, neutralization, adding of anti-interference or complexing matter, utilization of complex standards, and separation. The choice of methods is frequently governed by a knowledge of the chemistry of the compounds in the solution and on accuracy, speed, and efficiency requirements. (auth)

**13757** RADIOGRAVIMETRIC DETERMINATION OF POTASSIUM IN THE PRESENCE OF URANIUM AND THORIUM. Rodziewicz, Wlodzimierz; Grzedzicki, Kazimierz (Politechnika, Danzig). Chem. Anal. (Warsaw); 14: 1243-6(1969). (In Polish).

The optimum conditions for precipitation of potassium as potassium sodium cobaltinitrite in the presence of uranium and thorium were established. The results indicate that the concentration of uranium in the solution of potassium salt should not exceed $4 \times 10^{-1}$ mg U per 100 $cm^3$ and the gram-atom ratio of U:K should be smaller than $1.7 \times 10^{-4}$. For thorium the permissible concentration in the solution is approximately $10^{-1}$ mg Th per 100 $cm^3$ and the gram-atom ratio of Th:K should be smaller than $10^{-4}$. (auth)

**13758** SEPARATION BETWEEN Re–Mo–W, Mo–W WITH CELLULOSE ION EXCHANGER (DEAE). Kawabuchi, K. (Ehime Univ., Matsuyama, Japan). Bunseki Kiki; 7: 784-91(Dec 1969). (In Japanese).

The behavior of Mo, W, and Re toward diethylaminoethyl (DEAE) cellulose was investigated and consequently it was proved that the separation between Re–Mo–W or W–Mo, and the quantitative analysis of Mo and W in silicate rock and seawater could be achieved. By using an ion-exchange basic resin ($Cl^-$) DEAE cellulose, the distribution constants ($K_d$) of the elements were measured at various chloride ion concentrations and at various pH values. At any pH, the $K_d$ value decreased along with an increase of chloride ion concentration, and the maximum $K_d$ was at pH3 to 4. Accordingly at a certain $Cl^-$ concentration, three elements could be separated from each other by controlling the pH value. By this method the element could be isolated from the mixture within the following ratio, Re:Mo = 50,000:1 to 1:12,000, Re:W = 50,000:1 to 1:24,000. This method could be applied to the quantitative analysis of Mo and W in seawater and igneous rock, and the results were compared with other analytical methods. (NSA of Japan)

**13759** THIN LAYER CHROMATOGRAPHY OF RARE ELEMENTS. V. IDENTIFICATION AND SEPARATION OF RHENIUM(VII), MOLYBDENUM(VI), VANADIUM(V), AND TUNGSTEN(VI) IN MIXED SOLUTIONS OF SEVERAL ALCOHOLS. Gaibakyan, D. S. (Erevan State Univ.). Arm. Khim. Zh.; 22: 219-23(Mar 1969). (In Russian).

Microgram quantities of Re, Mo, V, and W were separated and identified on thin layer plates coated with alumina, using mixtures of aliphatic alcohols and additives such as acetic acid and HCl. The plates were sprayed with 10% $SnCl_2$ and 50% K rhodanate for development, producing orange, red, yellow, and yellow-green spots for Re, Mo, V, and W, respectively. The dependence of $R_f$'s, particularly that of Re, was studied for various combinations of methyl, ethyl, propyl, and butyl alcohols, water, acetic acid, and HCl. Separation of Mo from V was difficult in most systems but from other elements was better in some. In 50:10:50:10 butyl alcohol–methyl alcohol–acetic acid–HCl, the $R_f$ values of Re, Mo, V, and W were 0.48, 0.37, 0.32, and 0, respectively. In 50:50:25:25 butyl alcohol–methyl alcohol–HCl–water, these values were 0.68, 0.25, 0.92, and 0. (BBB)

**13760** ANALYTICAL APPLICATION OF X-RAY-EXCITED OPTICAL FLUORESCENCE SPECTRA. II. DIRECT DETERMINATION OF RARE EARTH ELEMENTS IN ALUMINUM OXIDE. Takashima, Kyoichiro; Nakajima, Tokunosuke (Japan Atomic Energy Research Inst., Tokai). Bunko Kenkyu; 18: 262-7 (Nov 1969). (In Japanese).

A direct, quantitative analytical technique for the determination of Gd, Dy, Eu, and Sm in $Al_2O_3$ using x-ray-excited optical fluorescence spectra is described. Rare earth elements were coprecipitated with host Al from acid solution as $Al(OH)_3$. Precipitated hydroxide was dried after centrifugal separation and then heated in a muffle furnace at 1000°C for 2 hr. These oxides were then heated at 1450°C in an electric resistance furnace for 60 sec. Such heating followed by quenching, prominently enhances the luminescent intensities of rare earth elements. It was shown by the x-ray diffraction method that the crystal of $Al_2O_3$ were transformed from gamma-type oxide to the stable alpha-type oxide during heat treatment. Concentrations of Gd, Dy, Sm, and Eu were determined by this method with detection limits ranging from 0.05 to 1.0 ppM. Reproducibility was found to be 5 to 10%. The enhancement and suppression effect due to Fe, Si, and Cu were investigated and discussed. (NSA of Japan)

**13761** THIN LAYER CHROMATOGRAPHY OF RARE ELEMENTS. IV. SEPARATION AND IDENTIFICATION OF RHENIUM(VII), MOLYBDENUM(VI), VANADIUM(V), AND TUNGSTEN(VI) IN ACIDIFIED BUTYL AND AMYL ALCOHOL SOLUTIONS. Gaibakyan, D. S. (Erevan State Univ.). Arm. Khim. Zh.; 22: 13-17(Jan 1969). (In Russian).

Separation of Mo from Re, V, and W is achieved at the μg level on alumina plates. Development of the plates was achieved with $SnCl_2$ and Na rhodanate. $R_f$ values are tabulated for various combinations of n-butyl, isobutyl, n-amyl, and isoamyl alcohol, HCl, $H_2O$, and acetic acid. In alcohol–HCl mixtures the $R_f$ values are strongly dependent on the relative volumes of alcohol and HCl present. In butanol–$H_2O$–HCl mixtures the $R_f$ is essentially independent of the concentration of HCl. In alcohol–acetic acid–HCl mixtures the $R_f$ decreases with decreasing HCl concentration. Excellent separation of Mo from Re and W was found in many systems studied, but the separation from V is generally poor. In 70:20:10 butyl alcohol–acetic acid–HCl, the $R_f$ values for Re, Mo, V, and W are 0.50, 0.38, 0.46, and 0.01, respectively; in 70:30 butyl alcohol–HCl, they are 0.90, 0.75, 0.68, and 0.14, respectively. (BBB)

## Isotopic Procedures

*Refer also to abstract 15867.*

**13762** K–Ar DATING USING NEUTRON ACTIVATION FOR Ar ANALYSIS: COMPARISON WITH ISOTOPE DILUTION Ar ANALYSES. Armstrong, Richard Lee (Yale Univ., New Haven). Geochim. Cosmochim. Acta; 34: 233-6(Feb 1970).

Isotope dilution Ar analyses are reported for all samples originally analyzed by neutron activation. The methods are in agreement but the more precise and accurate isotope dilution analyses are preferred. (auth) (UK)

**13763** REFERENCE MODELS FOR CLINICAL STUDIES BY ISOTOPE DILUTION. Moore, Francis D.; Hartsuck, James M.; Zollinger, Robert M.; Johnson, James E. (Harvard Medical School, Boston). Ann. Surg., 168: 671-700(Oct. 1968).

From 88th Annual Session of the American Surgical Association, Boston, Mass. See CONF-680458.

The determination of body composition by tracer dilution is discussed and models developed for dilution of tritiated water in total body water, of radioactive potassium in total body potassium, of radioactively labeled erythrocytes in the red cell volume, and of radiobromide in the extracellular fluid and the body chloride. (M.C.G.)

## Radiometric Procedures

*Refer also to abstracts 14015, 14181, 14260, 14282, 14287, and 14533.*

**13764** (CEA-R-3830) USE OF PROPORTIONAL COUNTER IN X-RAY SPECTROMETRY BETWEEN 5 AND 100 keV. APPLICATION TO THE DETECTION OF FISSION PRODUCTS AND TO THE DETERMINATION OF ABSOLUTE X-RAY EMISSION RATES. Cerf, Jean (Commissariat a l'Energie Atomique, Cadarache' (France). Centre d'Etudes Nucleaires). Nov 1969. 94p. (In French). Dep. CFSTI (U. S. Sales Only).

The measurement of electromagnetic radiations is difficult in the energy range 20 to 100 keV. A regular proportional counter was made suitable for this purpose by modifying both the nature and pressure of the gaseous mixture filling the detector volume. The CPEN-SAIP counter was selected. In the energy range considered, the counter is to be standardized with radioactive sources. Such standards were selected according to their disintegration schemes. Conditions of use (resolution, yield) of the CPN counter are defined as filled with an argon–methane mixture under a pressure of about 3 bars, in the energy range 5 to 100 keV. With such equipment, the absolute disintegration rate for the x rays of $^{133}Ba$ and $^{75}Se$ could be measured and a study made of a mixed fission products sample. In the same way, xenon-based gaseous mixtures were used to improve the detector yield. (auth)

**13765** (CEA-R-3877) RADIOCHEMICAL DETERMINATION OF $^7Be$ IN A FISSION-PRODUCT MIXTURE CONTAINING MANY INORGANIC SALTS. Prigent, Yvon; Van Kote, Francis (Commissariat a l'Energie Atomique, Bruyeres-le-Chatel (France). Centre d'Etudes). Nov 1969. 23p. (In French). Dep. CFSTI (U. S. Sales Only).

A radiochemical method is described for determining beryllium-7 in a mixture of fission products containing many inorganic salts. By studying the influence of various parameters it has been possible to speed up the decontamination on an anionic resin using an HCl–isopropanol mixture, as proposed by Korkisch, et al., (Talanta 11: p. 1157(1964)). $Be(OH)_2$ is first precipitated in the presence of EDTA; the main contaminants are then fixed on Dowex 1 × 10 in 12 M HCl and on Dowex 1 × 8 in a 3 M HCl (20 per cent)–

isopropanol (80 per cent) (vol/vol) mixture. The Be, which is not fixed, is precipitated by $NH_4H_2PO_4$ in the presence of EDTA, ignited as $Be_2P_2O_7$, filtered, weighed, and analyzed by gamma spectrometry. The method makes it possible to analyze 4 samples in 16 hrs with a chemical yield of 80 per cent, using a 4-day-old fission product solution. The overall decontamination factor exceeds $10^8$. (auth)

**13766** (NBS-TN-501) RADIOCHEMICAL ANALYSIS SECTION: MOESSBAUER SPECTROSCOPY, NUCLEAR CHEMISTRY, NUCLEAR INSTRUMENTATION, [AND] RADIOISOTOPE TECHNIQUES. Summary of Activities, July 1968–June 1969. DeVoe, James R. (ed.) (National Bureau of Standards, Washington, D. C.). Feb 1970. 149p. GPO $1.25.

Progress is reported on: Moessbauer spectroscopy, nuclear chemistry, nuclear instrumentation, radioisotope tracer techniques, and the application of statistics in nuclear and analytical chemistry. Variable-temperature devices for Moessbauer spectroscopy are being developed. Preliminary data on the detection of conversion electrons show the potential for Moessbauer spectroscopy in the field of chemical bonding in surfaces. Further exploration of the potential of Moessbauer spectroscopy for measurement of structural parameters of nickel compounds were made. Preliminary data are presented on the structure of iron-doped rutile ($TiO_2$) which is of significance to the determination of mineral structures found on the moon. Theoretical predictions of Moessbauer spectra resulting from electric field gradients due to crystal field interactions are presented. Evaluation of the basic integrals using the self-consistent Hartree–Fock method is given for ions of the first row of transition elements. Precautions to be taken in the analysis of gamma spectra are presented when model errors exist and when a gain shift is detected. A system for gas analysis that utilizes gas chromatography is described. Detection and measurement in the femtogram region are considered. The complete circuitry for the optical interferometric Moessbauer spectrometer is presented. Quantitative analysis for molybdenum and iron using radioisotope dilution is described. (auth)

**13767** (RLO–1750–54, pp 5–6) RADIOANALYSIS PROCEDURES. Larsen, Ingvar L. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Quantitative and qualitative determination of radionuclides in samples collected from the marine environment is accomplished by gamma spectroscopy. Sample counting rates are compared to rates for standards. (M.C.G.)

**13768** DETERMINATION OF $^{137}Cs$ IN WATERS. Bénes, Jaroslav (Nuclear Research Inst., Prague). Sb. Ved. Pr. Lek. Fak. Karlovy Univ. Hradci Kralove; 11: 477-81(1968).

A procedure is described for the concentration and isolation of $^{137}Cs$ that is suitable for its determination in waters. After some significant changes, the procedure may also be applied to the isolation of $^{137}Cs$ from all steps in the biological chain. Cesium is coprecipitated with a heavy metal ferrocyanide, preferably Fe(III), Mn, Co, Ni, Zn, Cu(II), and Pb. The precipitate of the heavy metal ferrocyanide, particularly Prussian Blue, containing the adsorbed Cs is dissolved in a warm saturated solution of EDTA at pH 10, and the Cs is extracted from the EDTA solution with dipicrylamine, and then the Cs is reprecipitated as tetraphenylborate. This procedure is suitable for the separation of Cs from mixtures containing K and other interfering elements such as Mg, Fe, and Na, in high concentrations. (B.L.M.)

**13769** MINERAL EXPLORATION OF THE OCEAN FLOOR BY IN SITU NEUTRON ABSORPTION USING A $^{252}Cf$ SOURCE. Senftle, F. E. (Geological Survey, Washington, D. C.); Duffey, Dick; Wiggins, P. F. Mar. Technol. Soc. J.; 3: 9-16(Sep-Oct 1969).

A technique showing the feasibility of using in situ neutron irradiation followed by detection of neutron capture gamma radiation for marine mineral exploration is described. Californium-252 is the source of neutrons, and a germanium-lithium drifted crystal is the $\gamma$ detector. The technique was used to obtain spectra of marine Mn nodules and Au ore (0.3 oz/ton) in a simulated marine environment. Although Cl presents some interference for some of the capture $\gamma$ peaks of Au and Mn, there appear to be several peaks for which there is no significant interference. Thus, good signatures can be obtained for these two elements, and it likewise appears that similar signatures can be obtained for many other elements in a marine environment. It was concluded that a marine exploration device based on the capture $\gamma$ method is feasible, and an outline sketch of such a unit is presented. (BBB)

**13770** NEW RADIOMETRIC TITRATION METHOD BASED ON SEPARATION BY MEANS OF ION EXCHANGE. II. THE DETERMINATION OF ZINC. Heijink, A.; Polak, H. L. (Univ. of Amsterdam). J. Radioanal. Chem.; 3: 359-68(Nov 1969).

The determination of zinc using EDTA was chosen as an example for the earlier suggested new radiocomplexometric titration procedure, in which phase separation is achieved by means of a strongly basic anion exchanger in the solution. Concentrations of zinc solutions down to $10^{-6}$M have been determined. The reverse titration, viz., of EDTA by zinc solution, which can be used as back-titration in complexometry, is also possible. However, theoretical relations for this latter type of titration are not simple. (auth)

**13771** DETERMINATION OF ISOTOPIC CARRIERS IN RADIOACTIVE PREPARATIONS OF HIGH SPECIFIC ACTIVITY BY RADIOMETRIC TITRATION. I. Knobloch, V.; Mudrova, B. (Inst. for Nuclear Research, Rez, Czech.). J. Radioanal. Chem.; 3: 387-91(Nov 1969). (In German).

The results of isotopic-carrier content determinations in radioactive preparations of high specific activity are presented. The method of radiometric titration in combination with paper electrophoresis is used. The optimal conditions for the estimation of some rare earth isotopes and $^{65}Zn$ have been determined. The method is suitable for checking the chemical purity of radioactive preparations; it is sufficiently rapid and sensitive, and only a sample of a few microliters is needed for the analysis. This simple and rapid method makes possible the instant routine control of preparations produced or used in the radiochemical laboratory. The method is suitable for the determination of elements forming stable, negatively charged complexes with EDTA. (auth)

**13772** ISOTOPIC ANALYSIS OF INDIUM AND LUTETIUM BY THERMAL NEUTRON ABSORPTION. Vasil'ev, S. S.; Velyus, L. M.; Korzh, P. D.; Fomenko, V. T. (Magnitogorsk Mining-Metallurgical Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 1, 127-9(1969). (In Russian).

A thermal neutron absorption method was used for determining $^{115}In$ in the mixture $^{113}In + ^{115}In$ and $^{176}Lu$ in $^{175}Lu + ^{176}Lu$. The optimum abundance ratios for indium and lutetium for isotopic analysis were selected by means of models. The intensity of the neutron flux passing through the specimen as a function of the content of the isotopes $^{176}Lu$ and $^{115}In$ for various weight specimens is given in a graph. Determination of $^{176}Lu$ at abundances above 60% demanded a specimen of 50 mg, for 30 to 60% $^{176}Lu$ a 100 mg specimen, and for 0 to 30%, 400 mg. For indium determination the specimen selected weighed 1000 mg. (R.V.J.)

**13773** DETERMINATION OF ISOTOPE CONTENT OF Eu AND Ir BY USING THERMAL NEUTRON METHOD. Vasil'ev, S. S.; Velyus, L. M.; Korzh, P. D.; Fomenko, V. T. At. Energ. (USSR); 28: 65-7(Jan 1970). (In Russian).

A thermal neutron absorption method was developed for the determination of europium and iridium isotopes. Graphs for determining $^{151}Eu$ and $^{191}Ir$ show relative intensities of neutron passage through the specimens vs. isotopic concentration. The absolute standard error for determination of $^{151}Eu$ was 0.22 and 0.43% with isotope concentrations of 0 to 30 and 30 to 100%, respectively, and for $^{191}Ir$ it was 0.85% with concentrations of 5.7 to 100%. Duration of the analysis was 30 min. (R.V.J.)

**13774** THORIUM, URANIUM, POTASSIUM, LEAD, STRONTIUM, AND RUBIDIUM IN SILICATE ROCKS BY GAMMA-SPECTROSCOPY AND/OR X-RAY FLUORESCENCE. Cherry, R. D.; Hobbs, J. B. M.; Erlank, A. J.; Willis, J. P. (Univ. of Cape Town, Rondebosch, South Africa). Can Spectrosc., 15: 3-9(Jan 1970).

Details are given of the determination of K, Th, and U by gamma spectroscopy and K, Th, Pb, Rb, and Sr by x-ray fluorescence in common silicate rocks. Analytical data for these elements are presented for six U.S.G.S. standard rocks. These data compare favorably with other recent data and demonstrate that reliable results may be obtained by both techniques in a wide variety of rock types provided that careful attention is paid to analytical detail and that corrections for absorption, background, etc., are properly evaluated. (auth) (Canada)

## *Activation Procedures*

*Refer also to abstracts 13809 and 14207.*

**13775** (CEA-R-2980(2)) ACTIVATION ANALYSIS. COUNTING OF SHORT HALF-LIFE RADIONUCLIDES. VOLUME II. PART C. ANALYTICAL PROGRAMS FOR DECAY CURVES. Junod, Eric (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Jan 1970. 55p. (In French). Dep. CFSTI (U. S. Sales Only).

The problems connected with the qualitative and quantitative analysis of the decay curves of a mixture of short half-life radionuclides are presented. A mathematical description of six basic

processes is given and some elements of FORTRAN programs are proposed. Two supplementary programs are drawn up for an overall processing of radionuclide determination in activation analysis. One is based on a simultaneous irradiation of the sample and of one or several check samples; the other on a separate irradiation of the sample and of the check sample. A dosimeter is used for the normalization of the irradiation conditions. (auth) (France)

**13776** (IS-T-341) ACTIVATION ANALYSIS WITH THERMAL AND FISSION NEUTRONS. Menapace, Laurene Mary (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 160p. Dep. CFSTI.

Thesis.

The technique of activation analysis was used for determination of three elements in their tungsten bronzes, $M_xWO_3$. An internal standard method of analysis was used in the nondestructive analysis of each bronze. Standards, containing a 1:1 weight ratio of the metal to be determined and tungsten, were prepared for each bronze investigated. Both standards and samples were irradiated simultaneously, and the counting ratio of W/M in the standards compared to the counting rate ratio in the bronze. The ratio of the counting rate ratios yields the M/W, or "x", value for each bronze. Potassium was determined by comparing the area under the 1.52 MeV photopeak from $^{41}K$ to the area under the photopeaks of interest associated with $^{187}W$. The $Ho_xWO_3$ bronzes were analyzed by comparing the area under the 1.38 MeV photopeak from $^{166}Ho$ to the $^{187}W$ activities. Lanthanum, in $La_xWO_3$, was determined by comparing the area under the 1.60 MeV photopeak of $^{140}La$ to $^{187}W$ photopeaks. The use of metastable states in activation analysis was also investigated. All determinations were made in two reactor locations: a thermal neutron facility was used and also a neutron converter assembly, which provided a high intensity source of fission neutrons. (auth)

**13777** (ORNL-4466, pp 62-88) NUCLEAR AND RADIOCHEMISTRY. Lyon, W. S.; Ross, H. H. (Oak Ridge National Lab., Tenn.).

Developments are reported for studies on: activation analysis of drug samples; delayed-neutron method for determination of fissionable materials; proton-reaction analysis for $^{12}C$, $^{13}C$, and $^{15}N$; determination of 0 by 14-MeV neutron activation; isotopic neutron source application; high-flux activation analysis laboratory; neutron cross sections and flux monitoring; radioisotope characteristics; half-life measurements; radioisotopic tagging of Cu cable with $^{110m}Ag$; polyethoxylated nonionic liquid surfactants in toluene for liquid scintillation counting of tritium samples in aqueous media; uranium isotope analysis; $^{134}Cs$ source scanning; fission product gas analysis; fission product release from reactor fuel microspheres; $\gamma$ radiolysis of iodide solutions; $\gamma$ radiation stability of standard pH buffers; stability of calomel and indicator electrodes to $\alpha$ and $\gamma$ radiation; determination of $H_2O_2$; homogeneous precipitations with radiolytically generated reagents; and spray and pool absorption technology program support. (P.C.H.)

**13778** (ORO-3922-1) RESEARCH IN CHARGED PARTICLE ACTIVATION ANALYSIS. Progress Report, May 1, 1969-January 31, 1970. Schweikert, E. A. (Texas Agricultural and Mechanical Univ., College Station. Activation Analysis Research Lab.). 31 Jan 1970. Contract AT(40-1)-3922. 41p. Dep. CFSTI.

Determination of traces of carbon or sulfur by activation methods using protons, deuterons, helium-3, and alpha particles is described. Upper limits of determinations using decay curve analysis and differential analysis are discussed. (M.C.G.)

**13779** A STUDY OF THE DISTRIBUTION OF THE LANTHANIDE ELEMENTS IN THE GULF OF MEXICO USING NEUTRON-ACTIVATION ANALYSIS. Hayes, David Wayne. College Station, Tex.; Texas A and M Univ. (1969). 179p.

Thesis.

A procedure for the determination of the lanthanide elements (LE) in seawater utilizing ferric hydroxide coprecipitation, U and Fe removal, neutron activation, and tracer level ion exchange separation was developed. The rapid ion exchange separation of all of the LE that could be accomplished in a period of 6 hr and without adjacent element interference was found. The procedures developed were employed in the determination of the LE in particulate (0.45 $\mu$) and soluble fractions in environmental samples. Lanthanide element concentrations in the open Gulf of Mexico were higher by an approximate factor of 3 when compared to other published values for the Atlantic and Pacific Oceans. A seaward decrease in the LE concentration was observed in the Gulf of Mexico, which could be correlated with river runoff. A depth profile in the Gulf of Mexico was similar to that observed for other trace elements, in that a maxima was located in the vicinity of 1000 m. The particulate fraction of a seawater sample contained approximately 50% of the total LE. In general the coastal waters exhibited a higher LE content in the particulate phase as opposed to the pelagic waters, and a slight decrease in the percent in the particulate phase was observed at 1000 m. In one analysis of the particulate phase it was found that 76% of the LE was in the 0.45 $\mu$ to 8 $\mu$ range and 24% in the 0.01 $\mu$ to 0.45 $\mu$ range. To relate the various degrees of LE fractionation observed in the oceans, the technique of least squares analysis of meteorite normalized LE data was employed ($\ln Y = A + BX$). Comparison of the slope coefficients (plotting) of the light and heavy LE enables the distinction of various water masses. LE fractionation of the sediments and other rocks could also be viewed, since the slope is dependent on relative abundance and not absolute abundances of the LE. The fractionation of the LE in seawater as compared to the sediments was immediately apparent. Previous work on the least squares analyses of North Atlantic Deep Water normalized LE data was recalculated and extended to include the Gulf of Mexico data. The plot of the intercept and slope coefficients revealed much the same information as the least squares analyses of meteoritic normalized data. Sediment distribution cannot be viewed as readily in this case because of the differences in relative LE distribution in seawater and sediments. In general more negative slopes (B) are obtained for waters in a coastal area as compared to pelagic areas, and this was attributed to the increase in terrestrial material (clays primarily). The least squares was applied to the LE content of the particulate and soluble fractions in the Gulf of Mexico. More negative slopes were found for the particulate phase as opposed to the soluble phase. Clays are known to exist in seawater and could account for the more negative character of the slope in the particulate phase. (Disser. Abstr.)

**13780** GAMMA-RAY DATA REDUCTION TECHNIQUE IN NEUTRON-ACTIVATION ANALYSIS. Del Callar, Achilles I. New York; New York Univ. (1969). 165p.

Thesis.

A technique capable of qualitative and quantitative determination of the isotopic components of an activated sample is presented. The $\gamma$ pulse-height distribution is divided into a number of consecutive sectors. An initial set of possible isotopes is obtained from the energies of the peaks in the composite spectrum. The decay of each energy sector is then analyzed using the decay constants from this initial set. This analysis proceeds from the highest to the lowest energy sector. Resolution of the decay curves is facilitated by such a sequence, since decay constants identified in higher energy sectors may be used as known components in lower energy sectors. Positive identification of the isotopes is achieved by the proper pairing of $\gamma$ energies and decay constants. Features that make this technique superior to existing methods in activation analysis include the elimination of the requirement for pure standard response functions and for prior information regarding the components in the sample. The technique is demonstrated with a sample containing eight isotopes with a total of thirty-six detectable $\gamma$ rays. (Disser. Abstr.)

**13781** DETERMINATION OF TRACE IMPURITIES IN INDIUM ANTIMONIDE BY NEUTRON ACTIVATION METHOD. Vasil'ev, I. Ya.; Razumova, G. N.; Shuba, I. D. Radiokhimiya; 11: 573-6 (1969). (In Russian).

Au, Se, Te, Ge, As, Cu, Zn, and Cd were determined as trace impurities in indium antimonide by neutron activation techniques. (M.C.G.)

**13782** MICROANALYSIS OF NITROGEN BY DIRECT OBSERVATION OF NUCLEAR REACTIONS. APPLICATIONS. Amsel, G.; David, D. (Ecole Normale Superieure, Paris). Rev. Phys. Appl.; 4: 383-91 (Sep 1969). (In French).

Microanalysis by the direct observation of nuclear reactions has been applied to the determination of $^{14}N$. The energy spectrum corresponding to this isotope, when bombarded with deuterons, was studied at various energies. The differential cross sections of the (d, p) and (d, $\alpha$) type reactions induced were measured from 600 keV to 1400 keV. The peak from the reaction $^{14}N(d, \alpha)^{12}C$, at an energy of about 10 MeV, is well isolated and allows the determination of nitrogen in the presence of most of the other nuclei. Other peaks of the spectrum may be used when isotopes like $^{10}B$ or $^{19}F$ are not present in the sample; counting rates may then be higher. Sensitivity of this nondestructive analytical method is of the order of $10^{-5}$ $\mu g/cm^2$. A 1 $mm^2$ sample may be easily analyzed. Using tantalum nitride as a standard, an absolute measurement of the amount of nitrogen is obtained. The application of these techniques to the study of reactive sputtering showed the influence of nitrogen partial pressure on the composition of the nitride films formed. Other applications to the study of the nitration of various metals in hot ammonia are also described. (auth)

**13783** DETERMINATION OF MANGANESE, COPPER, ZINC, AND CADMIUM IN GALLIUM ARSENIDE BY RADIOACTIVATION

ANALYSIS BASED ON THE QUANTITATIVE ISOTOPE DILUTION PRINCIPLE. Kudo, K.; Hishinuma, N. (Nippon Telegraph and Telephone Public Corp., Ibaraki, Japan). J. Radioanal. Chem.; 3: 369-76(Nov 1969).

A radioactivation analysis method has been developed for the determination of Mn, Cu, Zn, and Cd impurities in gallium arsenide. After irradiation, arsenic and gallium are separated by distillation and solvent extraction, then the impurity elements are determined by substoichiometric methods. Mn is extracted as tetraphenylarsonium permanganate into chloroform, and other elements as dithizonates in carbon tetrachloride under various conditions. The contents of Mn, Cu, Zn, and Cd in a gallium arsenide crystal with a carrier concentration of $1.8 \cdot 10^{16}$/cc were 0.004, 0.02, 0.006, and 0.04 ppM, respectively. (auth)

**13784** USE OF VERY SHORT-LIVED NUCLIDES IN NONDESTRUCTIVE ACTIVATION ANALYSIS WITH FAST SHUTTLE RABBIT. II. DETERMINATION OF LEAD BY MEANS OF $^{207m}$Pb. Wiernik, M.; Amiel, S. (Soreq Nuclear Research Centre, Yavne, Israel). J. Radioanal. Chem.; 3: 393-403(Nov 1969).

The use of 0.80 sec $^{207m}$Pb for the nondestructive determination of lead is described. The 0.570 MeV gamma activity is measured, and corrections are made to allow for the rapid decrease of the dead-time during the measurements. A sensitivity of about 1400 cps/mg Pb and a precision of ±4% were obtained with a neutron flux of $5 \times 10^{12}$ n · cm$^{-2}$ · sec$^{-1}$. The influence of possible interferences was studied. The fast shuttle rabbit used in this type of analysis is described. (auth)

**13785** SUBSTOICHIOMETRIC DETERMINATION OF PALLADIUM BY NEUTRON ACTIVATION ANALYSIS. Doctor, Z. K.; Haidar, B. C. (Inst. of Science, Bombay). J. Radioanal. Chem.; 3: 405-11(Nov 1969).

A method is described for the substoichiometric determination of traces of palladium by neutron activation analysis involving the extraction of palladium with isonitrosoacetophenone. The senstivity of the method is 0.005 μg of Pd. With 200 mg of silver alloy containing 0.0005% palladium, the average of three determinations of Pd is 0.98 μg, which varies between 1.07 μg and 0.91 μg at 95% confidence limit. The time required for radiochemical purification and counting of the sample does not exceed 12 minutes. (auth)

**13786** DETERMINATION OF CARBON IN SOME PURE METALS BY IRRADIATION WITH γ PHOTONS. Revel, G. (Centre d'Etudes de Chimie Metallurgique, Vitry-sur-Seine, France). J. Radioanal. Chem.; 3: 421-9(Nov 1969). (In French).

A method is described for the determination of carbon in iron, chromium, nickel, and molybdenum, using the $^{12}C(\gamma,n)^{11}C$ reaction. The samples are irradiated with the bremsstrahlung from a 35-MeV electron beam impinging a platinum target. Two apparatuses for the separation of carbon are described. The $^{11}C^*$ activity of the samples is compared with the activities of two graphite standards, counting the positron annihilation gamma rays. The limit of detection is 0.02 μg/g of carbon in high-purity iron. (auth)

**13787** COMPILATION OF SECOND ORDER REACTION INTERFERNENCES. PART I. Op de Beeck, J. P. (Univ., Ghent). J. Radioanal. Chem.; 3: 431-46(Nov 1969).

Calculations were made concerning the reactions of the following general type: Nuclide 1 (n,γ) Nuclide 2 (β decay) Nuclide 3 (n,γ) Nuclide 4, which can be an interference in thermal neutron activation analysis if the element corresponding to Nuclide 3 is to be determined in the presence of large amounts of the element corresponding to Nuclide 1. A survey of the table of isotopes revealed a total of 104 cases in which reactions of this type can occur. In 39 cases the reaction is not important for activation analysis purposes. For the remaining 65 cases the computer program SECORD was written in FORTRAN IV code, to calculate the interference expressed as apparent (i.e. false) concentration in ppM. Calculations were made for a single thermal neutron flux value of $5 \times 10^{12}$ n · cm$^{-2}$ sec$^{-1}$. Three tables are given on: second order reactions whose interferences have been numerically evaluated; second order reactions that are considered to be of less importance, together with the relevant remarks; and the interferences for 25 reactions. Information on the 40 remaining cases will be published later. (P.C.H.)

**13788** ACTIVATION ANALYSIS LABORATORY OF THE JOINT NUCLEAR RESEARCH CENTER OF THE EUROPEAN COMMUNITY AT ISPRA, ITALY. J. Radioanal. Chem.; 3: 447-51(Nov 1969).

A description is given of the activation analysis laboratory of the Joint Nuclear Research Center of the European Community at Ispra, Italy, including staff and physical characteristics. The laboratory was set up in 1960 as a part of the Nuclear Chemistry Service, to provide an activation analysis service for the necessities of the Ispra Center, and to develop techniques. (P.C.H.)

**13789** QUANTITATIVE DETERMINATION OF THE IMPURITIES IN NUCLEAR GRAPHITES BY THE METHODS OF SYSTEMATIC RADIOACTIVATION ANALYSIS. May, S.; Pinte, G. (CEN de Saclay, Gif-sur-Yvette, France). J. Radioanal. Chem.; 3: 329-43(Nov 1969). (In French).

Impurities contained in nuclear graphites have been determined so far individually. A method of systematic analysis is described that permits the determination of about twenty impurities in one sample, such as the following elements: Ag, Se, Hg, Sb, Cu, Fe, Ga, Co, Cd, Zn, In, Zr, Cr, Sc, Ba, Ca, Na, K, Rb, and Cs. Brief mention is made of methods used for the determination of all rare earth metals, Si, S, and P, as well as the elements that can be determined without chemical separation, such as Cl, Mn, and V. (auth)

**13790** ISOTOPIC DETERMINATION OF $^{43}$Ca BY PROTON ACTIVATION. Brits, R. J. N.; Peisach, M. (Southern Universities Nuclear Inst., Faure, S. Afr.). J. Radioanal. Chem.; 3: 345-51(Nov 1969).

An activation analysis method has been developed for the routine determination of $^{43}$Ca. The calcium is chemically separated and converted to fluoride. When activated for 2 hours with 4.50-MeV protons, $^{43}$Sc and $^{45}$Sc are produced and the ratio of their activities is a measure of the isotopic concentrations of $^{43}$Ca. $^{45}$Ca serves as an internal standard to represent total natural calcium. The relative standard deviation is ±1.5% and the method can determine a change of +0.004 atom % $^{43}$Ca in natural calcium. $^{42}$Ca may interfere, if present in enriched concentrations. (auth)

**13791** POSSIBILITY OF REMOVING THE EFFECT OF SAMPLE HUMIDITY ON THE ACCURACY OF NEUTRON ACTIVATION ANALYSIS. Belyakov, M. A.; Anchevskii, E. V. Zavod. Lab.; 35: 1364-6(1969). (In Russian).

A method was developed for neutron activation analysis of wet samples to exclude the effect of humidity on the accuracy of the measurements. Cadmium screens are used with the Po–Be neutron source to regulate the neutron beam. (tr-auth)

**13792** SOME PROCEDURES FOR THE SIMPLIFIED INTERPRETATION OF TWO-COMPONENT PHOTOPEAKS. Kryzhenkova, N. A.; Valieva, M. G.; Kist, A. A.; Usmanova, M. M.; Lobanov, E. M. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk Uzb. SSR, Ser. Fiz.-Mat. Nauk; No. 5, 68-70(1969). (In Russian).

Evaluation of multicomponent photopeaks obtained in γ-spectrometric activation analysis for the identification of isotopes is a laborious process. To simplify methods based on the analysis of Gaussian distribution curves, the differences in the half-lives of the component were used for the mathematical analysis. The theoretical derivations were experimentally verified on pyrolytic graphite specimens containing admixtures of dysprosium and samarium in ratios of 1:1 and 1:100. The standard deviation of the method was about 6%. By using the new scheme, the time required for the interpretation of two-component photopeaks was considerably reduced. (TTT)

**13793** DETERMINATION OF DEUTERIUM IN HEAVY WATER BY SECONDARY DEUTERON ACTIVATION. Pretorius, R.; Wainerdi, R. E. (Texas A and M Univ., College Station). Talanta; 17: 51-9(Jan 1970).

The deuterium concentration of heavy water was determined by utilizing recoiling deuterium nuclei from n-d collisions to induce the reaction $^{16}O(d,n)^{17}F$. The internal ratio of 66-sec $^{17}F$ to 7.35-sec $^{16}N$ activity, formed by the reaction $^{16}O(n,p)^{16}N$, was found to vary linearly with deuterium concentration. When such an internal ratio of activities is measured, the neutron flux and sample weight need not be known. Deuterium was determined over the range from 2.6 to 94.5 at.%, with a relative standard deviation of 2.8%. The effect of sample size was investigated and it was found that the relative amount of $^{17}F$ activity formed became less as sample size decreased, due to the loss of recoiling deuterons from the sample. A simple relationship to account for this effect was obtained. (auth) (UK)

**13794** RADIATION-BASED DETERMINATION OF COPPER IN NATURAL WATERS. Abdullaev, A. A.; Khamidova, R.; Zhuk, L. I.; Khatamov, Sh. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk Uzb. SSR, Ser. Fiz.-Mat. Nauk; No. 5, 75-6 (1969). (In Russian).

A direct method was developed for the determination of trace concentrations of copper in natural waters by means of neutron activation analysis. The γ emission of $^{64}$Cu, formed by the $^{63}Cu(n,\gamma)$ $^{64}$Cu reaction, served as the basis of the method. The effective cross section of activation of this reaction is 3.9 barn; the natural mixture contains 69.1% of $^{64}$Cu, the half-life of which is 12.8 hr. A scintillation γ spectrometer was used to determine the induced $^{64}$Cu energy, resulting from the irradiation of the specimens in a

thermal-neutron flux of $1.2 \times 10^{12}$ n/cm$^2$ for 1 to 5 hours. After exposure, Cu carrier was added, precipitating out the sulfide with $H_2S$. The extent of radiochemical separation was determined on the basis of the 0.51-MeV photopeak. The difference between the chemical and activation analysis data amounted to less than 6.9%. (TTT)

**13795** NONDESTRUCTIVE NEUTRON ACTIVATION ANALYSIS FOR TRACE IMPURITIES IN NIOBIUM. Rodriguez, F. A.; Gage, S. J.; Ralls, K. M. (Univ. of Texas, Austin). pp 373-8 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23-25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

A completely nondestructive approach to the radioactivation analysis of niobium is described. This method is based on the development of a systematic irradiation-counting procedure and the use of computer techniques to analyze the complex gamma ray spectra. The samples of metallurgical grade niobium powder and the high-purity standards (Al, Ca, Cr, Cu, Fe, Mo, Mn, Na, Nb, Ni, Sb, Si, Sn, Ta, Ti, and W) were irradiated in the 250-kW TRIGA-I Nuclear Reactor. The activated samples and standards were counted with a 3" × 3" NaI(Tl) crystal 2 minutes, 1 hour, and 1 day after irradiation and the gamma-ray spectra were recorded with a 256-channel pulse-height analyzer. The complex spectra of the samples were then analyzed using the computer program ALPHA-M which employs the method of linear least-squares. This technique is proving useful in the evaluation of niobium stock to be employed in superconductivity research. (auth)

**13796** ON THE NONDESTRUCTIVE NEUTRON ACTIVATION METHOD FOR THE DETERMINATION OF LITHIUM, BASED ON A SECONDARY NUCLEAR REACTION WITH TRITONS. Nikolov, K.; Todorovsky, D. (Univ. of Sofia). Isotopenpraxis; 5: 408-13(Nov 1969).

The possibilities of nondestructive neutron activation determination of lithium without the use of apparatus or measurement of gamma-gamma coincidences are considered. The most important sources of error were investigated and it was shown how these could be eliminated. The sensitivity of the nondestructive method without using gamma-gamma coincidence was found to be about $10^{-6}$ g Li. The presence of sodium in the samples does not impair the accuracy of the measurement when the quantity of sodium is not higher than $10^{-5}$ g. The error rises to 11% when the quantity of sodium present in the sample is about $10^{-4}$ g. The accuracy of the destructive and nondestructive neutron activation methods for the determination of lithium could also be influenced by certain parallel nuclear reactions with tritons. In this connection the influence of sulfur on the neutron activation determination of lithium was investigated. A formula for calculating the optimal cooling time and the counting time of the sample was established, designed to diminish the influence of sulfur on the results of the analysis. (auth)

## Inorganic, Organic, and Physical Chemistry

*Refer also to abstracts 13728, 13732, 13751, 13873, 13874, 13879, 13971, 13998, 14004, 14101, 14646, 14658, 14736, 14876, 14877, 14900, 14919, 14938, 14950, 14952, 15404, and 16218.*

**13797** (IAE-1831) SUBLIMATION OF AMERICIUM TETRAFLUORIDE. Chudinov, E. G.; Choporov, D. Ya. (Akademiya Nauk SSSR, Moscow. Institut Atomnoi Energii). 1969. 12p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The volatility of solid americium tetrafluoride was measured by the differential version of the Knudsen method. The data conform to the following equation in the interval 456 to 635°C: 1 g $p_{mm} = -11911.5/T + 9.34$. $AmF_4$ is thermodynamically unstable above 635°C. (JPRS)

**13798** (IJS-247) SYNTHESIS AND REACTIVITY OF URANIUM MONOSULFIDE. Komac, M.; Zupan, J. (Institut Jozef Stefan, Ljubljana (Yugoslavia)). Sep 1969. 9p. (In Slovenian). (CONF-690636-1). Dep. CFSTI (U. S. Sales Only).

From Yugoslavia Conference on Industrial Chemistry, Belgrade, Yugoslavia.

The direct synthesis of uranium monosulfide is described and reactivity of the product was examined. The systems CaS-US and BaS-US were investigated by means of x-ray, magnetic, and differential thermal analyses. In both systems appearance of the new phases was observed. (auth)

**13799** (ORNL-4400, pp 1-29) CHEMICAL STUDIES OF MOLTEN-SALT SYSTEMS. (Oak Ridge National Lab., Tenn.).

Progress is reported on: a polymer model for $LiF-BeF_2$ melts, viscosity and density of molten $BeF_2-LiF$ solutions, oxide-fluoride equilibria, a reference electrode in molten fluorides, ionic transport properties in molten fluorides, electric conductance measurements in molten salts, apparatus and techniques for spectroscopic measurements in fluoride media, and crystal structures of complex fluorides. (M.C.G.)

**13800** (ORNL-4400, pp 69-76) ELECTRICAL CONDUCTANCE OF AQUEOUS ELECTROLYTES TO 800°C AND 4000 BARS. (Oak Ridge National Lab., Tenn.).

Studies were made on: electric conductances of aqueous sodium iodide and the comparative thermodynamic behavior of aqueous sodium halide solutions, electric conductances of alkali metal halide solutions, ion product of water to 800°C from electric conductance behavior of ammonium bromide solutions and related electrolytes, electric conductances of $KNO_3$ solutions, and electric conductances of aqueous $(CH_3)_4NBr$ solutions. (M.C.G.)

**13801** (ORNL-4400, pp 77-92) PHYSICAL CHEMISTRY OF HIGH-TEMPERATURE AQUEOUS SOLUTIONS. (Oak Ridge National Lab., Tenn.).

Studies are reported on: equilibrium quotients at 25°C for $CaSO_4$ in several aqueous mixed-electrolyte solutions, solubility of $Fe_3O_4$ at elevated temperatures, fluoride complexes of beryllium(II) in aqueous media, correlation of $\Delta H$ and $\Delta S$ for the association of rare earth ions with fluoride, empirical relationships for stability of inorganic fluoride complexes, apparatus for emf titrations at elevated temperatures, a flowing emf cell for measurements at elevated temperatures, effect of solvent on the electrochemistry of iron, and an improved high-temperature isopiestic unit. (M.C.G.)

**13802** (ORNL-4400, pp 93-102) DIFFUSION PROCESSES. (Oak Ridge National Lab., Tenn.).

Progress is reported on: diffusion studies in noble gas systems, studies on thermal transpiration, determination of the viscosity coefficients of gases, studies of the self-diffusion of $^{14}C$ in pyrocarbon structures, gas transport studies in vented fuel elements and control rods, and development of simplified counterdiffusion apparatus for characterizing vents and vent components. (M.C.G.)

**13803** (ORNL-4400, pp 142-6) SPECIAL NUCLEAR SAFETY STUDIES. (Oak Ridge National Lab., Tenn.).

Research progress is reported on: ignition of charcoal adsorbers by fission product decay heat, kinetics of the steam-graphite reaction, and effect of water vapor on the volatility of fission product oxides. (M.C.G.)

**13804** (ORNL-4400, pp 158-63) SURFACE CHEMISTRY. (Oak Ridge National Lab., Tenn.).

Studies are reported on: heats of immersion in the $ZrO_2-H_2O$ system, adsorption of water vapor on thorium oxide between 25 and 500°C, the influence of surface water on the adsorption of nitrogen on thorium oxide, and the infrared spectra of thorium oxide surfaces and adsorbed water. (M.C.G.)

**13805** (ORNL-4466, pp 102-3) INORGANIC PREPARATIONS. LaValle, D. E.; Quincy, R. B. (Oak Ridge National Lab., Tenn.).

The various inorganic compounds that were prepared for different divisions at ORNL are discussed. (P.C.H.)

**13806** (ORNL-4505) RATES OF GAS EVOLUTION FROM THE REACTIONS OF URANIUM NITRIDE AND CARBONITRIDES WITH NITRIC ACID. Sears, Mildred Bradley (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 14p. Dep. CFSTI.

Gas evolution, as a function of time, is shown graphically for the reactions of −10 + 100 mesh specimens of UN, $UN_{0.77}C_{0.23}$, and $UC_{0.88}N_{0.25}$ with 0.5 to 15.8 M $HNO_3$. (auth)

**13807** (ORO-2954-3) PRECIPITATION FROM HOMOGENEOUS SOLUTIONS OF MIXED SOLVENTS. Final Technical Report. Howick, Lester C. (Arkansas Univ., Fayetteville). 15 Dec 1969. Contract AT(40-1)-2954. 8p. Dep. CFSTI.

Experiments were conducted on the growth of copper(II) 8-hydroxyquinolate and nickel(II) dimethylglyoximate from acetone-water solvents. It was concluded from these and preceding studies that the chemical reaction involved in the formation of insoluble material may be influenced by solvent composition and, although this was not the case in the two systems studied here, may be the rate-determining factor in the crystal growth processes. Solvent composition changes can change the mechanism in a crystal growth process either by altering the rate of the slow step in the formation, as is the case in the nickel(II) dimethylglyoximate

system, or by causing the formation of a new solid phase, as was the case in the copper(II) 9-hydroxyquinolate system. It was demonstrated that the presence of organic solvents in aqueous solutions may affect the number of heterogeneous nuclei which can function as catalysts for the crystal growth process. (J.G.B.)

**13808** (ORO-3234-16) TRACER AND ISOTOPE EFFECT STUDIES IN ORGANIC CHEMISTRY. Annual Progress Report. Fry, Arthur (Arkansas Univ., Fayetteville. Dept. of Chemistry). 1 Feb 1970. Contract AT(40-1)-3234. 140p. Dep. CFSTI.

Progress is reported on isotope effect studies, mechanisms of acid-catalyzed rearrangements of carbonyl compounds, $^{15}N$ and $^{18}O$ exchange studies, and $^{18}O$ tracer studies of neighboring group participation in photochemical hydration of double and triple bonds. (M.C.G.)

**13809** (RLO-1750-54, pp 33-6) CHEMICAL WATERMASS TRACER. Hanson, Peter J.; Forster, William O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Research is being carried out to develop a watermass tracer that can be activated by neutron activation. Eu, Tb, Sc, In, Co, Cr, Sb, and Cs were tested for solution stability in river water and sediments. (M.C.G.)

**13810** (RLO-1750-54, pp 37-42) THE CHANGING FORM OF THE RADIONUCLIDES $^{65}Zn$ AND $^{51}Cr$ DOWNRIVER FROM THE DALLES TO ASTORIA, OREGON IN DECEMBER 1966. Forster, W. O.; Osterberg, C. L.; Hanson, P. J. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Changes in the forms of chromium and zinc as they move down the Columbia River into the brackish estuary were studied. The regular decrease downstream in soluble and particulate activities of both $^{51}Cr$ and $^{65}Zn$ is shown. (M.C.G.)

**13811** (RLO-2017-1) TECHNETIUM AS A CATALYST IN ORGANIC REACTIONS. Interim Report. Blackham, Angus U.; Palmer, James L. (Brigham Young Univ., Provo, Utah. Dept. of Chemistry). 15 Jun 1968. Contract AT(45-1)-2017. 51p. Dep. CFSTI.

Technetium was shown to have activity in the catalytic conversion of n-heptane to toluene. The significance of this reaction along with a few other model reactions is that technetium has a potential use in the catalytic reforming of petroleum fractions. The most activity was shown by the catalyst prepared by impregnating a solution of ammonium pertechnetate on alumina, drying, and reducing in hydrogen. One of the best determinations gave about 70% conversion of n-heptane to products of which 90% was toluene at 500°C and a contact time 3 seconds. An oxidative regeneration of these technetium catalysts was effected. Molecular oxygen at 500°C oxidizes the catalyst without loss of the technetium as volatile oxides. The catalyst after reduction in hydrogen showed activity approaching that of the fresh catalyst. The activity for isomerization was overshadowed by the dehydrogenation activity. An attempt to isomerize n-pentane to isopentane resulted in the formation of olefins instead. This pronounced dehydrogenation activity was also shown by the almost quantitative conversion of methylcyclohexane to toluene. In the presence of sulfur compounds such as methyl mercaptan and thiophene the technetium catalyst still has activity for converting n-heptane to toluene. A reaction of technetium chlorocarbonyl, aluminum chloride, and ethylene to produce an ethylene complex of technetium was attempted. Infrared spectrophotomeric examination gave no evidence for the formation of the complex. However, further experiments in this study will be conducted later. (auth)

**13812** (UCRL-18887, pp 88-124) BIOPHYSICAL CHEMISTRY AND BIOPHYSICS. (California Univ., Berkeley. Lawrence Radiation Lab.).

Developments are reported for studies on the complete determination of the alignment of $CH_2Cl_2-CD_2Cl_2$ molecules in poly-γ-benzyl-L-glutamate solution by the NMR of $^{35}Cl$, D, and H. Also comparison was made of the electric and magnetic ordering. (P.C.H.)

**13813** STRUCTURAL EFFECTS ON ELECTRONIC RELAXATION PROCESSES OF ALIPHATIC KETONE TRIPLETS AT 77°K. O'Sullivan, M.; Testa, A. C. (St. John's Univ., Jamaica, N. Y.). J. Amer. Chem. Soc.; 92: 258-61 (28 Jan 1970).

The phosphorescence quantum yields and lifetimes of aliphatic ketones were determined at 77°K in EPA (mixed solvent of ethyl ether-isopentane-ethanol). The results indicate that the α-CH stretching mode is a significant factor in radiationless decay, i.e., $T_1 \sim S_0$. The phosphorescence quantum yields of the carbonyl compounds were observed to increase with alkyl substitution at the α carbon, and the phosphorescence wavelength maxima remained constant at 450 ± 3 nm. The results show that the natural radiative lifetime for phosphorescence is constant, while radiationless deactivation of the triplet is slowed down by substitution. The phosphorescence yield of di-t-butyl ketone in EPA at 77°K was determined to be 0.89 ± 0.10, which is greater than that of acetone by a factor of 21. Deuterated acetone exhibits enhanced phosphorescence relative to ordinary acetone. A comparison of absorption and phosphorescence data illustrates that the natural radiative lifetime for singlet and triplet are constant for the nine aliphatic ketones studied. (auth)

**13814** DEUTERON MAGNETIC RELAXATION STUDIES ON THE SOLUTION PROPERTIES OF SOME DENATURING AGENTS AND SURFACTANTS. Glasel, Jay A. (Columbia Univ., New York). J. Amer. Chem. Soc., 92: 372-5 (28 Jan 1970).

Deuteron relaxation times in $D_2O$ solutions of urea, acetone, guanidine hydrochloride, dimethyl sulfoxide, t-butyl alcohol, sodium dodecyl sulfate, and several commercial surfactants are reported. The observed interaction of these with water at low concentration is analyzed and discussed. It is of the same order of magnitude as water-ion interactions. Properties of compound formation between dimethyl sulfoxide and water at high solute concentrations are also discussed. The results indicate $3H_2O$-DMSO as the formula of the complex and this is compared with the results of other methods. (auth)

**13815** LABELING WITH $^{123}I$. THE REACTIVITY OF $^{123}I$ FORMED BY THE DECAY OF $^{123}Xe$. Welch, Michael J. (Washington Univ., St. Louis). J. Amer. Chem. Soc.; 92: 408-9 (28 Jan 1970).

The reactivity of iodine-123 produced by the decay of xenon-123 was evaluated and compared with the reactivity of iodine species produced directly by nuclear recoil and β-produced iodine formed in uranium fission. The xenon-123 generator-produced iodine-123 was found to be active and, with gaseous methane and benzene at 77°K, to have a reactivity similar to that of iodine atoms produced by nuclear recoil and in contrast to the reactivity of β-produced iodine. It was also found that the generator-produced species will label compounds of biological interest under carrier-free conditions. (J.G.B.)

**13816** FLASH PHOTOSENSITIZATIONS BY CADMIUM AND ZINC ATOMS. Young, P. J.; Greig, G.; Strausz, O. P. (Univ. of Alberta, Edmonton). J. Amer. Chem. Soc.; 92: 413-15 (28 Jan 1970).

A flash photolysis-kinetic spectroscopic technique for investigating vapor phase reactions of metal atoms at room temperature in their ground or excited states irrespective of vapor pressure is discussed. Results are reported on the dimethylcadmium (DMC) system. When DMC was flashed in the presence of $D_2$, $CD_4$, and $i\text{-}C_4D_{10}$ a shift of some 10 Å was observed in the hydride spectrum corresponding to the formation of CdD. This is evidence for the photosensitization reactions of excited cadmium atoms. (J.G.B.)

**13817** ISOTOPIC EXCHANGE INDUCED BY EXCITATION OF THE IODINE-IODOBENZENE CHARGE-TRANSFER COMPLEX. Levy, A. (Nuclear Research Center, Negev, Israel); Meyerstein, D.; Ottolenghi, M. J. Amer. Chem. Soc.; 92: 418-20 (28 Jan 1970).

The photochemically induced isotopic exchange between radioactive iodine and iodoaromatic compounds was investigated. Experimental evidence indicates that in the iodine-iodobenzene (PhI)-methylcyclohexane solution the photochemical exchange is not induced by excitation of either $I_2$ or $PhI_2$ but rather by light absorption within the charge transfer band of the $PhI \cdot I_2$ complex. (J.G.B.)

**13818** ISOLATION OF THE $^{229}Th$ ISOTOPE AND INVESTIGATION OF ITS SPECTROSCOPIC PROPERTIES. Egorov, V. N.; Korinfskaya, M. F.; Markov, V. K. Radiokhimiya; 11: 560-5 (1969). (In Russian).

The hyperfine structure and isotopic effect in the atomic spectrum of $^{229}Th$ were studied. Data from this investigation were used for determination of the spin and estimation of the nuclear deformation of $^{229}Th$ and for calculation of the isotopic shift constant. The method for isolation and purification of this isotope is given. (M.C.G.)

**13819** STUDY OF THE ADSORPTION OF AMERICIUM ON THE SURFACE OF POLISHED PLATINUM. Samartseva, A. G. Radiokhimiya; 11: 502-10 (1969). (In Russian).

The adsorption of americium by the surface of polished platinum in nitric acid solutions was studied as a function of the hydrogen ion concentration from $10^{-1}$ to $10^{-12}$ M. Up to pH = 2 the adsorption of americium was insignificant, 1 to 2%. At pH = 2 to 3 the adsorption of the radioactive element increased sharply up to 99 to 100%. Maximum adsorption extended up to pH = 6.5 to 7.0, after which it

decreased sharply to 20 to 25%. It was concluded that the shape increase in concentration is caused by the decrease in concentration of hydrogen ions in the solution and by the start-of hydrolysis of americum. It is postulated that the mechanism of adsorption of americium by platinum included initial adsorption of anions on the surface of the sorbent. (M.C.G.)

**13820** STUDY OF THE COMPLEX FORMATION OF Am(III) WITH $Cl^-$ IONS IN AQUEOUS SOLUTIONS BY SPECTROPHOTOMETRY. Barbanel, Yu. A.; Mikhailova, N. K. Radiokhimiya; 11: 595-8(1969). (In Russian).

An attempt was made to obtain quantitative data on the formation of Am(III) complexes from the change in optical density of its solutions in the region of f-f transitions, and particularly in the area of 500 to 505 nm, where the most intensive absorption peak was located. Data were obtained in the range of chloride concentration up to 9M. (M.C.G.)

**13821** URANIUM(IV) HEXAMETHYLENEDIAMINETETRAACETATE. Merkusheva, S. A.; Skorik, N. A.; Serebrennikov, V. V. Radiokhimiya; 11: 600-1(1969). (In Russian).

Uranium hexamethylenediaminetetraacetate with the formula $U(H_{20}C_{14}O_8N_2)$ was synthesized and the solubility of this compound in perchloric acid solutions determined. The stability constant and solubility product of the compound were determined. (M.C.G.)

**13822** ISOTOPIC EXCHANGE INVESTIGATIONS ON SILICATE ION EXCHANGERS. X. THE KINETICS OF THE SELF-DIFFUSION OF Ba AND Sr IONS IN SYNTHETIC ZEOLITES. Hoinkis, E.; Levi, H. W. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Z. Naturforsch.; 24a: 1784-90(Nov 1969). (In German).

Isotopic exchange in Ba and Sr Zeolite X was investigated over the entire range of the process. A special solution of the diffusion equation for the relevant case was applied to evaluate self-diffusion measurements. The diffusion process was found to be nonuniform. It was shown that 80% of the exchangeable Ba ions and 65% of the Sr ions diffuse with a high diffusion coefficient and the remainder with a low one. They differ by four to five orders of magnitude at room temperature. In the temperature range 120 to 0°C the activation enthalpy for the slow process is about twice as high as for the fast process. This behavior is explained in terms of cation location in the Zeolite X lattice. The cations are accommodated in two types of channel systems which are assumed to be separated from each other at least with respect to alkaline earth ions. The cation position within the channel systems are discussed. (auth)

**13823** THE SYNTHESIS OF POTENTIAL ANTIRADIATION COMPOUNDS, DERIVATIVES OF p-AMINOTHIOPHENONES. Shukla, Ravindra Shivprasad. Lincoln, Neb.; Univ. of Nebraska (1969). 67p.

Thesis.

Potential antiradiation compounds incorporating the protective moieties from both the substances, such as cyanides, that offer protection in mammals primarily by producing systematic hypoxia and those substances, such as thiols, that offer protection in vivo and in vitro were prepared. The compounds are derivatives of p-aminothiophenones. p-Acetylamino-$\alpha$-chloropropiophenone, p-acetylamino-$\beta$-chloropropiophenone, and p-acetylaminophenacyl chloride on refluxing with thiourea in alcoholic solution yielded p-acetylaminopropiophenyl-$\alpha$-isothiouronium hydrochloride, p-acetylaminopropiopenyl-$\beta$-isothiouronium hydrochloride, and p-acetylaminophenacylisothiouronium hydrochloride, respectively. These latter compounds on base hydrolyses failed to yield corresponding disulfides and on acid hydrolyses produced thiazole derivatives instead of their respective deacetylated isothiouronium salts. Bis(p-acetylaminopropiophenyl)-$\alpha$-disulfide, bis(p-acetylaminopropiophenyl)-$\beta$-disulfide and bis(p-acetylaminophenacyl) disulfide were synthesized by reacting p-acetylamino-$\alpha$-chloropropiophenone, p-acetylamino-$\beta$-chloropropiophenone and p-acetylaminophenacyl chloride with sodium thiosulfate to form their corresponding Bunte Salts and their subsequent hydrolyses by iodine. Acid hydrolyses of these Bunte salts followed by the treatment with ammonia resulted in formation of bis(p-aminopropiophenyl)-$\alpha$-disulfide, bis(p-aminopropiophenyl)-$\beta$-disulfide and bis(p-aminophenacyl) disulfide, respectively. (Disser. Abstr.)

**13824** STUDY OF THE OXYGEN ISOTOPE EXCHANGE IN MOLECULAR OXYGEN–RARE EARTH ELEMENT OXIDE SYSTEMS. Minachev, Kh. M.; Antoshin, G. V. Kinet. Katal.; 12: 159-63(1968). (In Russian).

The kinetics of isotope exchange between O and rare earth oxides and the catalytic properties of these oxides with respect to the reaction $^{16}O_2 + {}^{18}O_2 \rightleftharpoons 2\ {}^{16}O^{18}O$ were studied at 250 to 420°C at oxygen pressures of 10 to 80 mm Hg. The properties observed were found to be a periodic function of the electron structure of the rare earth elements. It was shown that catalysis of isotope exchange in molecular oxygen by rare earth elements takes place by exchange between molecular oxygen and the surface oxygen of the oxides. (JPRS)

**13825** STRETCHING FREQUENCIES OF ISOTOPIC ARSENATE AND PERMANGANATE IONS IN AQUEOUS SOLUTIONS. Pinchas, S. (Weizmann Inst. of Science, Rehovoth, Israel). Israel J. Chem.; 7: 5-10(Jan-Feb 1969).

Infrared absorption of crystalline powders and $D_2O$ solutions of normal and 84.5 at. % $^{18}O$-labeled $Na_3AsO_4$ as well as normal and 83.3 at. % $^{18}O$-labeled $NaMnO_4$ was measured in the 780 to 980 $cm^{-1}$ region. The antisymmetric $\nu_3$ stretching fundamental of the aqueous $As^{18}O_4^{3-}$ ion is decreased by 865 – 822 = 43 $cm^{-1}$. The isotopic shift observed for $\nu_3$ compares well with the isotopic shift of 40 $cm^{-1}$ found for the As = $^{18}O$ stretching frequency of $^{18}O$-triphenylarsine oxide. The $\nu_1$ vibration of the $As^{18}O_4^{3-}$ ions undergoes an isotopic shift of 26 $cm^{-1}$ as compared with the value of 48 $cm^{-1}$ calculated for the $^{18}O$-isotopic shift in the case of the $\nu_1$ fundamental of tetrahedral $XO_4$ ions. The discrepancy seems to be due to the fact that in aqueous solutions these ions are hydrated. In the hydrated $AsO_4^{3-}$ ion, the water molecules appear to be attached to the As atom. The $MnO_4^-$ ion behaves similarly to the $AsO_4^{3-}$ ion both with respect to the effect of the aqueous solvent on the crystalline $\nu_3$ X-$^{16}O$ stretching frequency ($MnO_4^-$: an increase of 917 – 904 = 13 $cm^{-1}$; $AsO_4^{3-}$: an increase of 865 – 851 = 14 $cm^{-1}$) and in regards to the $^{18}O$-isotopic shift of the aqueous solution $\nu_3$ frequency ($MnO_4^-$: 878 – 917 = –39 $cm^{-1}$). The behavior of $MnO_4^-$ seems to stem from the lower free negative electric charge, shared by the four oxygen atoms of the permanganate anion, making the H bonding between the ion and the water molecules that hydrate it weaker and less important in affecting its stretching frequencies. (BBB)

**13826** A SPECTROPHOTOMETRIC STUDY OF TRIVALENT ACTINIDE COMPLEXES IN SOLUTION. IV. AMERICIUM WITH CHLORIDE LIGANDS. Marcus, Y.; Shiloh, M. (Israel Atomic Energy Commission, Yavne). Israel J. Chem.; 7: 31-43(Jan-Feb 1969).

The absorption spectra of Am(III) in ethanol, concentrated aqueous LiCl solutions, and long-chain alkylammonium chloride solutions in aromatic diluents were obtained, as well as those of certain solid double salts and complexes. A strong $5f^6 \rightarrow 5f^56d^1$ transition was observed in the aqueous solutions at 235 nm (42,500 $cm^{-1}$), and from the dependence of the intensity of this and the 503 nm (19,880 $cm^{-1}$) band on the effective chloride activity, the stability constants of the inner sphere complexes were determined: $AmCl^{2+}$, $\log\beta_1^* = -2.21 \pm 0.08$, and $AmCl_2^+$, $\log\beta_2^* = -4.70 \pm 0.08$. Double Am(III) – Cs chlorides, double Am(III) – tetrabutylammonium chlorides, double Am(III) – tetraethylammonium chlorides, and double Am(III) – tridodecylammonium chlorides were prepared. The spectrum of the long-chain amine extracts is comparable to that of solids of the composition $AmCl_3 \cdot 2N(C_4H_9)_4Cl \cdot XLiCl$. The proposed 6-coordination for the amine extracts, based on their spectra, is consistent with the species that has been proposed on the extraction data. The hypersensitive nature of some of the bands is discussed. An explanation in terms of an asymmetric field, which contradicts the octahedral nature of the species, is consistent with the presence of the excess chloride, required to stabilize the species producing this spectrum. The evidence does not permit the definite assignment of a coordination number and local symmetry to Am(III) in the amine extracts, nor in any of the solid materials examined. (BBB)

**13827** LYATE-CATALYZED ISOTOPIC EXCHANGE OF AROMATIC LYONS IN DICHLOROBENZOATES AND RELATED ANIONS IN PROTIUM AND DEUTERIUM OXIDES. Milhaven, M. John Regis. New York; Fordham Univ. (1969). 94p.

Thesis.

The equilibria and rates of the isotopic exchange of m-dichloroaromatic compounds in an alkaline medium were studied in some detail with 2,4-dichlorobenzoate and 2,4-dichlorobenzoate-3d, and with 3,5-dichlorobenzoate and 3,5-dichlorobenzoate-4d. The assumptions that the rate of exchange of protium-deuterium in an isotopically mixed aqueous system was linearly dependent on the percentage of deuterium in the system, and that the mechanism involved a carbonionic intermediate were drawn from literature references and enabled two types of isotope effects to be discussed. The primary kinetic isotope effects of this system showed that the rate of the protonated acid exchanging in protonated or deuterated media was faster than the rate of a deuterated acid exchanging in the same medium. The solvent isotope effect comparing the same reaction in deuteroxide-deuterium oxide as in hydroxide-protium oxide was consistent with the hypothesis that the transition state in the systems studied was a three-centered "reactant-like" arrangement consisting of the organic "dianion," the proton (or deuteron) and the lyoxide ion. This supposition of the structure of the

transition state was further strengthened by the thermodynamic properties calculated from experimental data. The reaction system was extended to a series of herbicides having substituted phenyl groups. In all cases but one, electron-withdrawing groups ortho at each side of the reacting carbon were necessary to cause isotopic exchange. (Disser. Abstr.)

**13828** DEUTERIUM ISOTOPE EFFECTS ON SOLVOLYSIS RATES OF CYCLOPENTYL BROSYLATES AND TOSYLATES. Christen, Jimmie Duane. Rolla, Mo.; Univ. of Missouri (1969). 105p.

Thesis.

The brosylates and tosylates of cyclopentanol and its 1-$d_1$, cis-2-$d_1$, trans-2-$d_1$, and 2,2,5,5-$d_4$ analogs were synthesized and their solvolysis rates measured at 25° in 70 vol % ethanol–water. The solvolysis reactions were monitored by a conductance method. The isotope effects, $k_H/k_D$, observed for the brosylates and tosylates of each of the isotopically substituted cyclopentyl alcohols are as follows: 1-$d_1$-brosylate (1.1869) and 1-$d_1$-tosylate (1.1836); cis-2-$d_1$-brosylate (1.1533) and cis-2-$d_1$-tosylate (1.1577); trans-2-$d_1$-brosylate (1.1803) and trans-2-$d_1$-tosylate (1.1765); 2,2,5,5-$d_4$-brosylate (1.8881) and 2,2,5,5-$d_4$-tosylate (1.8863). The closeness in magnitude of the isotope effects for the cis- and trans-isomers is important in that it shows the cyclopentyl system to be very nearly planar. A great difference would have indicated that the ring was quite puckered. More important, however, is the fact that the trans-isotope effect is greater than the cis-isotope effect. This means that specific solvation of the β-hydrogens, leading to an elimination driving force, is a possible explanation of secondary deuterium isotope effects. The isotope effects for the $d_4$-compositions were calculated by taking the product of the squares of the cis- and trans-isotope effects. The calculated isotope effect was 1.8530 for the $d_4$-brosylate and 1.8552 for the $d_4$-tosylate. These values are very near the observed values of 1.8881 and 1.8863 for the brosylate and tosylate, respectively. Because of the great precision (~0.1 to 0.2%) of the technique used in obtaining these results, the difference between the calculated and the observed isotope effects for both the brosylate and tosylate is considered to be a true difference. However, the closeness of the calculated and observed values does indicate an almost cumulative isotope effect, which supports the hyperconjugation postulate as a possible explanation of secondary deuterium isotope rate effects. There is a very close agreement between the isotope effects for the brosylate and tosylate of any given isotopically substituted cyclopentyl alcohol, e.g., the greatest difference exhibited was that of 0.38% for the cis-compounds. This close agreement tends to indicate that when changing from one leaving group to another structurally similar leaving group there is a negligible influence on the isotope effect. Unsuccessful attempts were made to synthesize 2,2-$d_2$-cyclopentyl alcohol and cis-2-$d_1$-5,5-$d_2$-cyclopentyl alcohol and the procedures are described. (Disser. Abstr.)

**13829** MECHANISM AND REACTIVITY FOR A SERIES OF HYDROLYTIC REACTIONS. Pletcher, Terry Carl. Bloomington, Ind.; Indiana Univ. (1969). 130p.

Thesis.

The rates of hydrolysis of 2,2,2-trifluoroethyl-, 2-methoxyethyl-, and ethyl N-methylacetimidate in aqueous solution were investigated in the pH range 1 to 10 at 25°C. The approximately linear correlation of the infrared stretching frequency of the O-D bond of deuteriomethanol with the basicity of hydrogen-bonding partners was employed to estimate the values of $pK_a$ for the conjugate acids of certain acetals, ketals, and ortho esters: 2,2-dimethoxypropane, -5.2; methyl orthoacetate, -6.5; methyl orthocarbonate, -8.4. Second-order rate constants for the acid-catalyzed hydrolysis of triethyl orthoformate-α-$d_1$, propionaldehyde diethylacetal-α-$d_1$, and the corresponding protium compounds were measured spectrophotometrically at 25°C in slightly acidic solvents. Values of the α-deuterium isotope effect ($k_h/k_d$) were determined to be 1.05 + 0.01 for the ortho ester and 1.17 + 0.01 for the acetal. These values establish that the transition state structures for ortho ester and acetal hydrolysis differ substantially. In particular, the transition state for acetal hydrolysis must have a geometry close to that for the carbonium ion intermediate while that for ortho ester hydrolysis more nearly resembles the substrate. These results suggest that electron donation by resonance will be more important in stabilizing the transition state for acetal hydrolysis than in stabilizing that for ortho ester hydrolysis. (Disser. Abstr.)

**13830** SORPTION OF AQUEOUS PLUTONIUM ON SILICA SURFACES. Rozzell, Thomas Clifton. Pittsburgh; Univ. of Pittsburgh (1969). 163p.

Thesis.

The sorption of aqueous plutonium(IV) onto silica surfaces was studied as a function of pH, ionic strength, temperature, bicarbonate concentration, age of the Pu solution, the amount of Pu presorbed, silica particle size, Pu concentration, phosphate concentration, and rate of solution agitation. Most of these variables not only play a considerable role in the plutonium-silica interaction, but also affect the particle size distributions of the aqueous colloidal Pu. The rate of sorption was shown to be diffusion limited with various size Pu species diffusing, but not all adhering to the silica surface. The double layer potential barrier influences the sorption process. There was a reduction in the sorption rate, which appears to be associated with the expected formation of negatively charged colloids (both true and pseudo) and the simultaneous reduction in the number of positively charged ionic and low-molecular weight colloidal species. Centrifugation and autoradiographic techniques were used to study the Pu particle size distribution in the liquids and on the silica surface, respectively. By use of the autoradiographic method it was possible to show that the primary sorbing species were particles whose maximum diameter was 0.004 microns ($4 \times 10^{-7}$ cm). This technique appears to give definitive information concerning the nature of the sorbing species. In the desorption studies it was found that approximately ⅔ of the sorbed Pu desorbed within several hours, while the remaining ⅓ was tightly bound and appeared to desorb with a 1 year half-time. On the basis of the laboratory studies on sorption and desorption, predictions were made concerning the likely behavior of Pu(IV) in natural waters. (Disser. Abstr.)

**13831** ORGANIC COMPOUNDS OF URANIUM(V). I. REACTIONS OF URANIUM PENTAETHOXIDE WITH CARBOXYLIC ACIDS. Dubey, S.; Bhandari, A. M.; Kapoor, R. N. (Jodhpur Univ., India). Z. Naturforsch.; 25b: 18-22(Jan 1970).

Reactions of carboxylic acids in different stoichiometric ratios have been carried out under anhydrous conditions, and compounds of the type $U(OEt)_4$ $(OOCR)$, $U(OEt)_3$ $(OOCR)_2$, $U(OEt)_2$ $(OOCR)_3$, and $U(OEt)$ $(OOCR)_4$ (where R is $CH_3$, $C_2H_5$, $C_3H_7$, and $C_6H_5$) have been isolated. Lactic acid yielded compounds of the type $U(OEt)_3$ $(C_3H_4O_3)$, $U(OEt)$ $(C_3H_4O_3)_3$, $U_2(C_3H_5O_3)_5$, and $U(C_3H_4O_3)$ $(C_3H_5O_3)$. Determination of molecular weight of some of the soluble derivatives of benzoic acid, suggest that they are dimeric in boiling benzene. (auth)

**13832** HIGH TEMPERATURE REACTION BETWEEN URANIUM MONOCARBIDE AND β-SILICON CARBIDE. Ferguson, I. F.; Walker, D. E. Y. (Atomic Energy Authority, Springfields, Eng.). J. Chem. Soc.,A; 31: 35-7(1970).

β-Silicon carbide-coated uranium monocarbide granules were heated in the range from 1500 to 1850°C to investigate the compatibility of β-silicon carbide and uranium monocarbide. Above 1600°C a reaction occurred that can be summarized as: $9UC + 4SiC \rightarrow 5UC_2 + U_3C_2Si_2 + USi_2$. The reaction appears to involve the formation of a molten shell at the original β-silicon carbide–uranium monocarbide interface. It results in the diffusion of uranium into the β-silicon carbide according to the relation, $D = 0.01342 \exp(-68{,}000 \pm 20{,}000/RT)$. (auth) (UK)

**13833** MECHANISM OF THE REACTION OF NONSTOICHIOMETRIC URANIUM DIOXIDE WITH MOLYBDENUM. Shatalin, A. S.; Malykh, V. A.; Frolov, A. V.; Uporov, V. I. (Inst. of Physics and Power Engineering, Obninsk, USSR). Zh. Fiz. Khim.; 43: 2505-9(Oct 1969). (In Russian).

The reaction of molybdenum with nonstoichiometric uranium dioxide was studied at 800 to 1800°C. The oxidation of molybdenum by superstoichiometric oxygen from uranium dioxide, diffusion of this phase in the system, and the reduction of this phase to metallic molybdenum at temperatures above 1500°C were studied. (tr-auth)

**13834** KINETIC ISOTOPE EFFECT IN HIGH TEMPERATURE REDUCTION OF SULFATE. Grinenko, V. A.; Grinenko, L. N.; Zagryazhskaya, G. D. (Inst. of Geochemistry and Analytical Chemistry, Moscow. Central Research and Mining Inst. of Nonferrous, Rare, and Noble Metals, Moscow). Geochem. Int. (Engl. Transl.); 6: 370-6(1969).

Translated from Geokhimiya; No. 4, 484-91(1969).

At 100°C sulfuric acid was reduced by a HI, $H_3PO_2$, and HCl mixture to $H_2S$ and at 135°C by hydrogen to $SO_2$. At a high reduction rate at 290°C, S and $H_2S$ liberation was also noted. The coefficients of isotope fractionation are: 1.019; 1.0169; 1.014; 1.011; 1.010 for temperatures of 100, 138, 158, 210, 230, and 290°C, respectively. Experimental data and theoretical calculations of fractionation coefficients confirm the multistage character of the sulfate reduction process, the stage of reduction to sulfite being the slowest. (auth)

**13835** HEATS OF SUBLIMATION AND THE NATURE OF CHEMICAL BONDS OF RARE EARTH METALS. Gordienko, S. P. Zh. Fiz. Khim.; 43: 2359-60(Sep 1969). (In Russian).

A comparison of literature data on the heats of sublimation of rare earth metals and their electron structure showed that differences in the strength of chemical bonds of these metals are caused mainly by the degree of participation of the f-electrons. The fraction of f-electrons that participate in the formation of a chemical bond (the probability of f → d transitions) was estimated. Results are given for La, Ce, Pr, Nd, Pm, Sm, and Eu. (tr-auth)

**13836** STUDIES OF THE EQUILIBRIUM IN THE REDUCTION OF $Sm_2O_3$ BY CARBON. Kyshtobaeva, G. M.; Smagina, E. I.; Kutsev, V. S. (All-Union Inst. of Scientific and Technical Information, Moscow). Zh. Fiz. Khim.; 43: 2400-1(Sep 1969). (In Russian).

The thermodynamics of the reactions of graphite with samarium oxide were studied. On complete reduction of the $Sm_2O_3$, the materials contained no oxygen and had the gross composition $SmC_{1.71} + xC$, representing a mixture of SmC, Sm, and graphite. (M.C.G.)

**13837** ON THE MECHANISM OF THE SELF-INDUCED EXCHANGE OF TRITIUM WITH HALOGENATED ALIPHATIC HYDROCARBONS. Carr, Victoria; Ache, Hans J. (Virginia Polytechnic Inst., Blacksburg). Radiat. Res.; 41: 15-23(Jan 1970).

The self-induced exchange of tritium with dihalogenated aliphatic hydrocarbons, 1-chloro-3-iodopropane and 1-bromo-3-chloropropane, has been studied as a function of exposure time and tritium concentration. The iodine, bromine, chlorine, and hydrogen exchange rates were found to be a function of the bond dissociation energies involved. Since the weaker bonded atom is preferentially exchanged, this method can be used for the preparation of tritium-labeled compounds of highest specific activity. (auth)

**13838** URANYL ADSORPTION ON TITANIUM COALS. Yatsevskaya, M. I.; Ermolenko, N. F. Dokl. Akad. Nauk BSSR, 12: 1003-5(Nov. 1968). (In Russian).

A comparative study was made of the adsorption of $UO_2(NO_3)_2$ on original and titanium coals. Titanium coal was prepared by adsorptive saturation of the original coals with $TiCl_4$ vapor and subsequent hydrolysis to $TiO_2$. Forms with $TiO_2$ contents of 6.6 and 10.4% were used. Application of $TiO_2$ on coal led to a significant increase of its adsorptive activity for $UO_2(NO_3)_2$ under both static and dynamic conditions. (tr-auth)

**13839** THERMODYNAMIC ANALYSIS OF THE PROCESS OF PRODUCTION OF REFRACTORY TUNGSTEN-BASED CARBONYL MATERIALS. Syrkin, V. G.; Uzl'skii, A. A. Zh. Fiz. Khim.; 43: 2766-70(Nov 1969). (In Russian).

Several groups of possible reactions proceeding on thermal dissociation of tungsten hexacarbonyl were examined. The values of the isobaric potential were calculated at 300 to 1500°K. Reaction schemes for production of tungsten oxides and carbides are given. (M.C.G.)

**13840** THERMODYNAMIC STUDY OF THE SYSTEM YTTRIUM + YTTRIUM SESQUIOXIDE. A REFINEMENT OF THE VAPOR PRESSURE OF YTTRIUM. Ackermann, R. J.; Rauh, E. G.; Walters, R. R. (Argonne National Lab., Ill.). J. Chem. Thermodyn.; 2: 139-49(Jan 1970).

The mass effusion and mass spectrometric methods have been combined to measure over the temperature range 1340 to 2100°K the vapor pressure of solid and liquid yttrium and the partial pressure of yttrium in equilibrium with several metal solutions containing unsaturated and saturated amounts of sesquioxide. For pure yttrium the derived enthalpy of sublimation at 0°K was $\Delta H^0(0) = (100{,}330 \pm 500)$ cal $mol^{-1}$. The yttrium component in both solid and liquid solution of metal containing saturated and unsaturated amounts of oxide showed negative deviations from Raoult's law. The activity against composition diagram at 2000°K was constructed for the chosen components Y and $Y_2O_3$. The lower phase boundary of the sesquioxide was determined in the temperature range 1831 to 2076°K by an isopiestic method and the results showed a departure from ideal stoichiometry at all temperatures in this range and a composition of $Y_2O_{2.88}$ at the highest temperature. (auth) (UK)

**13841** PLUTONYL(VI) COMPLEXES WITH GLYCOLATE AND β-CHLOROPROPIONATE IN AQUEOUS SOLUTION. Portanova, R.; Cassol, A.; Magon, L.; Tomat, G. (CNR, Padua). J. Inorg. Nucl. Chem.; 32: 221-8(Jan 1970).

Complex formation of plutonyl(VI) with glycolate and β-chloropropionate was investigated by means of potentiometric $[H^+]$ measurements, and values of the complexity constants of the three mononuclear complexes were determined in perchlorate medium of ionic strength I = 1M at 20°C. The relationship between the stability of the plutonyl complex and the dissociation constant of the carboxylic acid corresponding to the respective ligand anion is discussed. (auth) (UK)

**13842** DENSITY AND SURFACE TENSION OF MOLTEN URANIUM TETRACHLORIDE. Desyatnik, V. N.; Nichkov, I. F.; Raspopin, S. P. (Ural Polytechnic Inst., Sverdlovsk, USSR). Izv. Vyssh. Ucheb. Zaved., Tsvet. Met.; No. 5, 95-8(1969). (In Russian).

The temperature relation of the density and surface tension of pure molten $UCl_4$ at 595 to 800°C was studied. Results of the measurement of surface tension were compared with calculated data and the deviation between them did not amount to 1%. (tr-auth)

**13843** ELECTRODE POTENTIALS OF SEVERAL REDOX COUPLES IN MOLTEN FLUORIDES. Jenkins, H. W.; Mamantov, G.; Manning, D. L. (Univ. of Tennessee, Knoxville. Oak Ridge National Lab., Tenn.). J. Electrochem. Soc.; 117: 183-5(Feb 1970).

The standard electrode potentials ($E^\circ$) of the following redox couples were determined in molten $LiF-BeF_2-ZrF_4$ (65.6–29.4–5.0 m/o (mole per cent) and $LiF-NaF-KF$ (46.5–11.5–42.0 m/o) at 500°C from emf measurements on galvanic cells using Ni(II)/Ni reference electrode, contained in a boron nitride compartment. The $E^\circ$ of the Ni(II)/Ni couple was set at 0.000V. In $LiF-BeF_2-ZrF_4$: Be(II)/Be –2.120V, Zr(IV)/Zr –1.792V (not $E^\circ$), Cr(II)/Cr –0.701V, Cr(III)/Cr(II) –0.514V, Fe(II)/Fe –0.410V, and Fe(III)/Fe(II) 0.166V. In $LiF-NaF-KF$: Fe(II)/Fe –0.390V and Fe(III)/Fe(II) –0.200V. The more anodic value of $E^\circ$ of the Fe(III)/Fe(II) couple (as compared to the Fe(II)/Fe couple) in $LiF-BeF_2-ZrF_4$ in comparison to $LiF-NaF-KF$ reflects the higher acidity (modified Lux-Flood concept) of the $LiF-BeF_2-ZrF_4$ melt. (auth)

**13844** FLUORESCENCE AND ENERGY TRANSFER IN $SrZnP_2O_7 : UO_2^{2+}$. Hoffman, M. V. (General Electric Co., Nela Park, Ohio). J. Electrochem. Soc.; 117: 227-32(Feb 1970).

An efficient green phosphor has been found in $SrZnP_2O_7 : UO_2^{2+}$. Optimum formulation of host matrix, cation substitutions, and activator concentrations have been made and tested in fluorescent lamps. The structure has not been determined, but it is suggested that it may be a $UO_2^{2+}$-stabilized structure differing from the apparent host matrix of $SrZnP_2O_7$. Efficient energy transfer by radiationless transfer has been found from $UO_2^{2+}$ to $Eu^{3+}$ and $Nd^{3+}$. (auth)

**13845** ISOTOPE EXCHANGE IN THE $GeH_4$–KOD–$D_2O$ SYSTEM. Allred, A. L.; Deming, Richard L. (Northwestern Univ., Evanston, Ill.). Inorg. Nucl. Chem. Lett., 6: 39-40(Jan 1970).

The experimental technique employed and the results which were obtained of hydrogen isotope exchange between germane and solutions of potassium deutoxide in deuterium oxide are reported. (UK)

**13846** HYDROGEN ISOTOPE EFFECTS IN THE INVERSION OF (–)-MENTHONE IN MIXTURES OF WATER AND DIMETHYL SULPHOXIDE. Bell, R. P.; Cox, B. G. (Univ. of Stirling, Scotland). J. Chem. Soc., B; No. 1, 194(1970).

The rate of inversion of ordinary and deuterated (–)-menthone was measured in solutions of sodium hydroxide in six solvents containing 0 to 75 mole percent of dimethyl sulphoxide. The kinetic isotope effect has a maximum value of $k^H/k^D = 6.5$ in a solvent containing 30 to 40 mole percent dimethyl sulphoxide, suggesting that the proton is approximately half transferred in the transition state. In agreement with this, published values of $H_-$ were used to show that the hydroxide ion and the anion of menthone have approximately the same basic strength in solvents of the above composition, and the variation of rate with $H_-$ corresponds to a Brönsted exponent $\beta = 0.48$. (auth) (UK)

**13847** ELECTROCHEMICAL STUDIES OF THE URANIUM (VI)–ETHYLENEDIAMINETETRAACETIC ACID COMPLEX. Baker, Blair C.; Sawyer, Donald T. (Univ. of California, Riverside). Inorg. Chem.; 9: 197-204(Feb 1970).

The electrochemistry of the 1:1 uranium(VI)–EDTA complex was investigated by cyclic voltammetry, controlled-potential coulometry, and chronopotentiometry at mercury and platinum electrodes. Between pH 5 and 7 the complex is reduced by two irreversible one-electron steps with a chemical step between them (an ECE mechanism) to a stable uranium-(IV)–EDTA species. At pH 6.4 and a scan rate of 0.02 V/sec the peak potential for reduction of the complex is –0.87 V vs. sec. On the basis of the electrochemical data and pH studies the electroactive species is $UO_2YH^-$ (Y represents the tetraanion of EDTA); its diffusion coefficient at 25° is $5.5 \times 10^{-6}$ $cm^2$/sec. The electron-transfer kinetic parameters $\alpha n_a$ and $k^f_{1,h}$ have values of 0.2 and $2.1 \times 10^{-5}$, respectively; mechanisms are proposed for reduction of the complex. (auth)

**13848** PROTON NUCLEAR MAGNETIC RESONANCE STUDIES OF URANIUM(IV)–ETHYLENEDIAMINETETRAACETIC ACID COMPLEXES. Ehman, Dewayne L.; Sawyer, Donald T. (Univ. of California, Riverside). Inorg. Chem.; 9: 204-11(Feb 1970).

The proton NMR spectrum of a 1:1 paramagnetic uranium(IV)–ethylenediaminetetraacetic acid complex (prepared by dissolving $U^{IV}(EDTA) \cdot 2H_2O$ in aqueous $Na_2SO_4$ solutions) has been studied as a function of pH and temperature. The magnetic moment of the complex is 3.01 BM as determined from the NMR data. Because of the anisotropy of the U(IV) unpaired electron spin at the ligand protons, the spectra exhibit extensive contact shifts (10 to 35 ppM). Above 45°C the spectrum consists of an AX pattern for the ligand acetate protons plus a singlet for the ethylenic group; the resonances broaden as the temperature is lowered. Below 7°C the broadened A resonance splits into two singlets and the X resonance becomes narrower; the ethylenic resonance splits into two singlets. On the basis of the NMR data a plausible solution structure for the complex is proposed as well as an exchange mechanism for the ligand protons. The exchange rates and their energies of activation were determined. Clear evidence that the NMR spectral displacements are due to pseudocontact shifts is given by the large differences in the chemical shift values for the methylenic protons of the ligand acetate groups. (auth)

**13849** SOLUBILITY OF CERIUM TRIFLUORIDE IN MOLTEN MIXTURES OF LITHIUM, BERYLLIUM, AND THORIUM FLUORIDES. Barton, Charles J.; Bredig, Max A.; Gilpatrick, L. O.; Fredricksen, Judy A. (Oak Ridge National Lab., Tenn.). Inorg. Chem.; 9: 307-11(Feb 1970).

The solubility of $CeF_3$ in eight $LiF-BeF_2-ThF_4$ and four $LiF-ThF_4$ mixtures was determined between 600 and 800°C by radiochemical and wet chemical methods. Sintered copper filter sticks were used to remove filtered samples of the molten fluoride mixtures that were saturated with $CeF_3$ tagged with $^{144}Ce$. The data are represented by straight lines in log (solubility) vs. 1/T plots, the slopes of which gave heats of solution. These data, together with published values for the solubility of $CeF_3$ in $LiF-BeF_2$ mixtures, permitted formulation of relationships between solubility and solvent composition that could be rationalized in terms of charge and size of the ions involved. (auth)

**13850** A PROTON MAGNETIC RESONANCE HYDRATION STUDY OF SCANDIUM, YTTRIUM, AND THORIUM PERCHLORATES IN WATER–ACETONE MIXTURES. Fratiello, Anthony; Lee, Robert E.; Schuster, Ronald E. (California State Coll., Los Angeles). Inorg. Chem.; 9: 391-2(Feb 1970).

A study was undertaken of scandium, yttrium, and thorium perchlorates to determine the maximum hydration numbers for the $Sc^{3+}$, $Y^{3+}$, and $Th^{4+}$ ions. PMR measurements were used. (M.C.G.)

**13851** INVESTIGATIONS ON ION EXCHANGE EQUILIBRIA WITH RADIOACTIVE TRACER METHOD. XVI. DETERMINATION OF THE STABILITY CONSTANTS OF NEGATIVELY CHARGED ZINC CHLORIDE COMPLEXES WITH THE AID OF LIQUID ANION EXCHANGER. Lengyel, T.; Toerko, J. (Inst. of Isotopes, Budapest). Acta Chim. Acad. Sci. Hung.; 62: 151-6 (1969).

Using liquid anion exchanger Amberlite LA-2, the formation constants of negatively charged chloro complexes of zinc were determined. For treatment of experimental data a graphic method was developed. The constants $\lg K_3 = -0.30$ and $\lg K_4 = -0.07$ seem to be reliable though the comparison with literature data is rather difficult as the values published previously show a large scattering. (auth)

**13852** SUBLIMATION OF AMERICIUM TETRAFLUORIDE. Chudinov, E. G.; Choporov, D. Ya. At. Energ. (USSR); 28: 62-4(Jan 1970). (In Russian).

The vapor pressure of americium tetrafluoride was determined from 456 to 668°C. It was revealed that the behavior of americium tetrafluoride was similar to that of plutonium tetrafluoride, which indicated that the dissociation mechanisms of these compounds are identical. (R.V.J.)

**13853** AN X-RAY STUDY OF α-OXALIC ACID DIHYDRATE, $(COOH)_2 \cdot 2H_2O$, AND OF ITS DEUTERIUM ANALOGUE, $(COOD)_2 \cdot 2D_2O$: ISOTOPE EFFECT IN HYDROGEN BONDING AND ANISOTROPIC EXTINCTION EFFECTS. Delaplane, Robert G.; Ibers, James A. (Northwestern Univ., Evanston, Ill.). Acta Crystallogr., Sect B; 2423-37(1969).

A three-dimensional x-ray diffraction study of the α-modification of both $(COOH)_2 \cdot 2H_2O$ and $(COOD)_2 \cdot 2D_2O$ was made. For each substance, intensity data were collected with Cu Kα radiation out to 110° in 2θ on a Picker automatic diffractometer. Positional and anisotropic thermal parameters for all atoms were refined on $F^2$ by full-matrix least-squares techniques. A correction for anisotropic extinction effects was included in the least-squares refinement. The weighted R factors on $F^2$ are 3.9% (547 observed reflections) for $\alpha$-$(COOH)_2 \cdot 2H_2O$ and 3.9% (555 observed reflections) for $\alpha$-$(COOD)_2 \cdot 2D_2O$. The corresponding conventional R factors on $F^2$ are 2.8% and 2.8% respectively; on F they are 2.0% and 2.3%. The oxalic acid molecules and water molecules are linked together by a three-dimensional network of hydrogen bonds. All three crystallographically independent O–H ··· O bond lengths expand significantly with deuteration while the bond lengths within the oxalate fragment remain unchanged. In $\alpha$-$(COOH)_2 \cdot 2H_2O$, the O–H ··· O distances are 2.512 (1), 2.864 (2), and 2.883 (1) Å; the corresponding O–D ··· O distances in $\alpha$-$(COOD)_2 \cdot 2D_2O$ are 2.531 (1), 2.880 (2), and 2.907 (1) Å. (auth) (Denmark)

**13854** NEUTRON DIFFRACTION STUDY OF HYDROGEN BONDING AND THERMAL MOTION IN DEUTERATED α AND β OXALIC ACID DIHYDRATE. Coppens, P.; Sabine, T. M. (Brookhaven National Lab., Upton, N. Y.). Acta Crystallogr., Sect. B; 25: 2442-51(1969).

A three-dimensional neutron diffraction study of the α and β modifications of deuterated oxalic acid dihydrate was made. The two structures are compared with particular reference to the D–O–D angles in the water molecules, which are respectively 105.8 ± 0.2° and 108.8 ± 0.2° in the α and β forms. It was concluded that the electronic structure of the water molecule is dependent on the hydrogen bonding environment. Rigid-body motion analysis of the oxalic acid molecules shows a larger vibration around the long molecular axis and excess vibration of the hydroxylic deuteron in the direction of the short hydrogen bond. The excess root mean square amplitude is in quantitative agreement with earlier infrared data. A discussion of the deuterium scattering length is given, and it is shown that this quantity cannot be less than 6.51 ± 0.02 fermi. (auth) (Denmark)

**13855** THE PHOTOINDUCED RING EXPANSION OF ARYLAROYLAZETIDINES. MECHANISTIC STUDIES AND CHARACTERIZATION OF THE EXCITED STATE. Padwa, Albert; Gruber, Robert (State Univ. of New York, Buffalo). J. Amer. Chem. Soc.; 92: 107-14(14 Jan 1970).

The photochemical rearrangement of arylaroylazetidines to diarylpyrroles was examined in mechanistic detail. The quantum efficiency of the photoreaction was low (Φ = 0.046) and increased slightly with deuterium substitution in the azetidine ring. Sensitization and emission studies indicate that the reaction is derived from the lowest triplet state. The failure of quench implies that the reaction of the ketone is too rapid for diffusion of the excited state to quencher molecule. A mechanism involving transfer of an electron from nitrogen to the excited triplet state followed by proton transfer and electron reorganization accounts for the observed rearrangement patterns. Reversal of hydrogen transfer rationalizes both the deuterium isotope effects and the low quantum efficiency of the reaction. (auth)

**13856** α-DEUTERIUM EFFECTS IN SN2 REACTIONS WITH SOLVENT. Shiner, V. J. Jr.; Rapp, M. W.; Pinnick, H. R. Jr. (Indiana Univ., Bloomington). J. Amer. Chem. Soc.; 92: 232-3 (14 Jan 1970).

Some α-deuterium rate effects are reported for some well-established SN2 type solvolyses of compounds. Results confirmed that the major determinant of the α-d effect is the nucleophilic (SN2) or limiting (SN1) character of the mechanism in solvolysis. (M.C.G.)

**13857** TRANSLATIONAL ENERGY DEPENDENCE OF THE BOND ENERGY EFFECT FOR ABSTRACTION FROM n-PERDEUTERIOBUTANE BY FAST HYDROGEN ATOMS. Gann, Richard George; Ollison, Will Mann; Dubrin, J. (Massachusetts Inst. of Tech., Cambridge). J. Amer. Chem. Soc.; 92: 450-4(11 Feb 1970).

Hydrogen atoms at various well-known initial kinetic energies, 0.67, 0.92, 1.15, 1.67, and 2.05 eV, were generated by the photodissociation of HI and HBr and reacted with $n\text{-}C_4D_{10}$ and $n\text{-}CD_3(CH_2)_2CD_3$. Abstraction at the weaker secondary C–D bonds was strongly favored over reaction at the primary positions (the bond energy effect was first observed in recoil systems, where the T was produced at essentially infinite energy on the chemical scale). The integrated yield ratio, HD(prim)/HD(sec), increased from 0.24 at the lowest source energy to 0.59 at the highest source energy. This significant energy dependence was consistent with a higher threshold energy for primary abstraction. At high relative energies (~2 eV), where the individual abstraction cross sections were only weakly energy dependent, the secondary cross section was ~30 to 50% greater than the primary cross section. (auth)

**13858** CARBONIUM IONS. XI. DEAMINATION OF 1-AMINOPROPANE AND THE QUESTION OF PROTONATED CYCLOPROPANE VS THE 1-PROPYL CATION. Karabatsos, Gerasimos J.; Orzech, Chester E. Jr.; Fry, James L.; Meyerson, Seymour (Michigan State Univ., East Lansing. American Oil Co., Whiting, Ind.). J. Amer. Chem. Soc.; 92: 606-14(11 Feb 1970).

The aqueous acid deaminations of 1-aminopropane-1,1-$d_2$, -2,2-$d_2$, -3,3,3-$d_3$, and -1-$^{13}C$ led to 1-propanols that were about

4% isotope-position rearranged and to 2-propanols that were exclusively isotope-position unrearranged, i.e., having arisen from a nominally irreversible 1,2-hydride shift. The percentage of 1-propanols with one deuterium atom at the α-carbon was the same from either the 1,1-$d_2$- or the 2,2-$d_2$-labeled amine; that with two deuterium atoms at the α-carbon was about the same from either the 2,2-$d_2$ or the 3,3,3-$d_3$ amine. The results were interpreted in terms of edge-protonated cyclopropane intermediates that account for about 6% of the overall yield of product. The mechanism of edge-protonated cyclopropane equilibration is pictured as occurring by a "pseudorotation," or equivalent process, about the carbon–carbon bond, that leads to simultaneous carbon–carbon and hydrogen–hydrogen scrambling, with the carbon–carbon scrambling being more extensive than the hydrogen–hydrogen. It is estimated that this process is about 5 to 10 times faster than capture of the protonated cyclopropane by water to give 1-propanol. Under the deamination conditions the edge-protonated cyclopropanes leak neither to the 1-propyl nor to the 2-propyl cation. (auth)

**13859** CARBONIUM IONS. XII. REACTION PATHS IN THE ISOMERIZATION OF BROMOPROPANES WITH ALUMINUM BROMIDE. Karabatsos, Gerasimos J.; Fry, James L.; Meyerson, Seymour (Michigan State Univ., East Lansing. American Oil Co., Whiting, Ind.). J. Amer. Chem. Soc.; 92: 614-20(11 Feb 1970).

The reactions of 1-bromopropane-1,1-$d_2$, -2,2-$d_2$, and -1-$^{13}C$ with aluminum bromide, in 6:1 mol:mol ratios, at 0°C for 5 to 6 min, yielded mixtures of 1-bromopropane and 2-bromopropane. The recovered 1-bromopropanes showed extensive hydrogen–hydrogen and carbon–carbon scrambling. The 2-bromopropanes were mainly isotope-position unrearranged, i.e., they arose primarily from a nominally irreversible 1,2-hydride shift. The paths producing isotope-position rearranged 1-bromopropanes are shown to be reversible 1,2-hydride shifts and protonated cyclopropane intermediates. The results, however, do not firmly rule out 1,2-methyl shifts as an alternative to protonated cyclopropanes. Bimolecular reactions, elimination-addition reactions, and intermolecular hydride transfers do not occur under such reaction conditions. At longer reaction times, when the concentration of 2-bromopropane is large, intermolecular hydride transfers do occur. They were detected by the formation of propane and by isotopic analysis of the products. The rearrangement of 2-bromopropane to 1-bromopropane occurs by two paths—an intramolecular 1,2-hydride shift, which is the major path, and an intermolecular hydride transfer. (auth)

**13860** CARBONIUM IONS. XIII. EFFECT OF SUBSTITUTION AT C-2 OF THE 1-PROPYL SYSTEM ON THE FORMATION OF PROTONATED CYCLOPROPANES. Karabatsos, Gerasimos J.; Hsi, Nelson; Meyerson, Seymour (Michigan State Univ., East Lansing. American Oil Co., Whiting, Ind.). J. Amer. Chem. Soc.; 92: 621-6(11 Feb 1970).

The aqueous acid deamination of isobutyl-1,1-$d_2$-amine gave a 70% yield of alcohols with the composition 72.5% t-butyl alcohol, 18.0% sec-butyl alcohol, and 10.5% isobutyl alcohol. The composition of the mixture obtained from deamination of the corresponding 2-d-amine was 64.0% t-butyl alcohol, 24.5% sec-butyl alcohol, and 11.5% isobutyl alcohol. The difference in the ratio of t-butyl to sec-butyl alcohol obtained from the two amines is ascribed to a $k_H/k_D$ isotope effect of about 1.5 for the intramolecular 1,2-hydride shift. The isobutyl alcohols were found to be exclusively isotope-position unrearranged, thus excluding protonated cyclopropane intermediates in their path of formation. The sec-butyl alcohols from the 1,1-$d_2$, and 2-d-amines were both isotope-position rearranged, about 7.6% and 9.1%, respectively. The path responsible for this rearrangement was established to be exclusively intramolecular 1,2-hydride shifts with a $k_H/k_D$ of about 1.3. Substitution of a methyl group for a hydrogen (isobutyl system) at C-2 of the 1-propyl system decreases the overall product arising from the protonated cyclopropane path from 6% in the deamination of n-propylamine to 0.6% in the deamination of isobutylamine. Substitution of two methyl groups (neopentyl system) decreases it to the point where no products arising from the protonated cyclopropane path have been detected. These differences have been explained in terms of the relative stabilities of the protonated cyclopropanes and their classical carbonium ion counterparts. (auth)

**13861** CHLORINE KINETIC ISOTOPE EFFECTS IN NUCLEOPHILIC DISPLACEMENTS AT A SATURATED CARBON. Grimsrud, Eric P.; Taylor, James W. (Univ. of Wisconsin, Madison). J. Amer. Chem. Soc.; 92: 739-41(11 Feb 1970).

The mechanism suggested by Benkeser for the interaction of tertiary amines with trichlorosilane was confirmed. Kinetics of deuterium exchange between trichlorosilane and tributylamine deuteriochloride were measured at 30°C. Within experimental error there was no kinetic isotope effect. (M.C.G.)

**13862** ON THE MECHANISM OF INTERACTION BETWEEN TERTIARY AMINES AND TRICHLOROSILANE. Bernstein, Stanley C. (Wright State Univ., Dayton, Ohio). J. Amer. Chem. Soc.; 92: 699-700(11 Feb 1970).

The reactions of various aliphatic and aromatic chlorides with both aromatic and aliphatic oxides and thiooxides in methanol were studied. The chlorine kinetic isotope effect was larger for reactions involving greater carbon–chlorine bond breaking in the transition state. (M.C.G.)

**13863** SITES ACTIVE FOR CATALYTIC HYDROGEN–DEUTERIUM EQUILIBRATION OVER α-CHROMIA. Selwood, P. W. (Univ. of California, Santa Barbara). J. Amer. Chem. Soc.; 92: 39-49(14 Jan 1970).

Hydrogen–deuterium equilibration measurements and parahydrogen conversion measurements were made on powdered ruby, chromia supported on α-alumina at various surface concentrations, and pure α-chromia. Pretreatment conditions were found for the development of strong catalytic equilibration activity on all samples. The results were interpreted in terms of surface structure, which appears, for this reaction, to involve a dihydroxylated chromium 3+ ion capable of releasing either a proton or molecular hydrogen, with simultaneous reversion to the 5+ oxidation state. The active chromium ion is not directly accessible to molecular hydrogen. The 2+ oxidation state is probably formed under certain conditions, but it does not participate in the hydrogen–deuterium equilibration reaction. Adjacent sites containing chromium are not necessary, but probably contribute to thermal stability. These conclusions are supported by a variety of related studies. (auth)

**13864** INFRARED MATRIX ISOLATION SPECTRUM OF THE METHYL RADICAL PRODUCED BY PYROLYSIS OF METHYL IODIDE AND DIMETHYL MERCURY. Snelson, Alan (IIT Research Inst., Chicago). J. Phys. Chem.; 74: 537-44(5 Feb 1970).

The matrix isolation technique was used to trap methyl radicals formed by the gas-phase pyrolysis of methyl iodide, $d_3$-methyl iodide, and dimethylmercury. The three observed infrared-active vibration frequencies of the $CH_3$ radical assuming a planar structure, point group $D_{3h}$, are $\nu_2 = 617\ cm^{-1}$, $\nu_3 = 3162\ cm^{-1}$, and $\nu_4 = 1396\ cm^{-1}$. The corresponding frequencies for $CD_3$ are $\nu_2 = 463\ cm^{-1}$, $\nu_3 = 2381\ cm^{-1}$, and $\nu_4 = 1026\ cm^{-1}$. The infrared-inactive frequency $\nu_1$ is calculated at 3044 and 2153 $cm^{-1}$ for $CH_3$ and $CD_3$, respectively, using the UBFF potential for an analysis of the vibrational modes. Some observations on the mechanisms of decomposition of methyl iodide and dimethylmercury under the present experimental conditions are made, and a tentative vibrational assignment for the radical $HgCH_3$ is given. (auth)

**13865** NEUTRON AND X-RAY CRYSTAL STRUCTURE OF $(Na,Li)_7Th_6F_{31}$ WITH MORE THAN ONE LEAST-SQUARES MINIMUM. Brunton, George; Sears, D. Richard (Oak Ridge National Lab., Tenn.). Acta Crystallogr., Sect. B; 25: 2519-27 (1969).

The compound $(Na,Li)_7Th_6F_{31}$ crystallizes in space group P3c1 with $a_0 = 9.9056 \pm 0.0003$ and $c_0 = 13.2820 \pm 0.0005$ Å at 25°C. The calculated density is 6.045 g $cm^{-3}$ and Z = 2. There are 18 atoms in the asymmetric unit. Two independent $Th^{4+}$ ions and F(1) through F(10) are on the general position 6(d); Th(1) is coordinated by $9F^-$ and Th(2) is coordinated by $10F^-$. Ion F(11) is on position 2(a). The three sodium ions Na(1), Na(2), and Na(3) occupy positions 2(c), 2(b), and 2(a) respectively. The ion Na(3) is surrounded by $12F^-$ and Na(2) and Na(1) are surrounded by $6F^-$ at distances less than 3.0 Å. Sodium(1) and Na(2) have five and three more $F^-$ nearest neighbors respectively between 3.0 and 3.5 Å. Lithium(1) is octahedrally coordinated at position 2(a). Lithium(2) is at general position 6(d) and is surrounded by $7F^-$ nearest neighbors less than 3.0 Å distant. There at least two least-squares minima for each of two sets of data obtained with x-rays and neutrons. The ranges of cation–anion interatomic distances for the originally determined x-ray and neutron minima are respectively: Th(1)–F, 2.23–2.62, 2.28–2.52 Å; Th(2)–F, 2.25–2.63, 2.29–2.57 Å; Na(1)–F, 2.26–3.54, 2.26–3.41 Å; Na(2)–F, 2.25–3.34, 2.30–3.07 Å; Na(3)–F, 2.56–2.96, 2.50–3.00 Å; Li(1)–F, 2.03–2.06, 1.96–2.06 Å; Li(2)–F, 1.77–2.89, 1.92–2.77 Å. Refinement of the x-ray parameters with neutron data, and vice versa, did not change the parameters significantly; two very significant minima remained, with differences as large as 30 σ. (auth)

**13866** DIRECT CONVERSION OF URANIUM CARBIDE TO $UCl_4$ BY GASEOUS REAGENTS. Mitamura, Takashi (Saitama Univ., Urawa, Japan); Kanno, Masayoshi. Denki Kagaku; 37: 235-9(Dec 1969). (In Japanese).

The reaction of UC with various chlorinating agents was studied using the thermal balance method in order to determine the utility of the chloride volatility process for reprocessing irradiated UC fuels. The experiments were carried out below 590°C, the melting point of $UCl_4$, to remove the free C formed and obtain pure $UCl_4$ in the product. The reaction of UC with $CCl_4$ diluted with Ar or $H_2$ was investigated at constant temperatures between 230 and 450°C. The reaction using $H_2$ as diluent indicated better results, but the complete removal of free C could not be attained. The reaction of UC with HCl showed ignition above 300°C, but controlled reaction of UC with HCl was attained by dilution with Ar. Where the partial pressure of HCl was 300 to 400 mmHg, the removal of free C was possible at 300°C and the product was almost pure $UCl_4$. (NSA of Japan)

**13867** NMR SPECTRA OF PARTIALLY DEUTERATED ACETONITRILE DISSOLVED IN THE NEMATIC PHASE. Diehl, P.; Khetrapal, C. L. (Univ., Basel). J. Magn. Resonance; 1: 524-6(Sep 1969).

The NMR spectra of some partially deuterated molecules oriented in the nematic phase of liquid crystals were studied to provide information about isotopic effects on the molecular geometry and the orientation. The proton and the deuteron magnetic resonance spectra of partially deuterated acetonitrile were examined in the nematic phase of a mixture of 50% 4-methoxy benzylidene-4-amino-α-methyl-cinnamic acid *n*-propyl ester and 50% anisole–azophenyl *n*-capronate at room temperature (27°C). The proton spectra of the various isotopic species showed direct couplings with deuterons. The isotopic substitution was shown to reduce the orientation parameter by about 0.5% per deuteron substitution. The orientation parameter (weighted mean of the various species) obtained from the proton spectrum was used to determine the deuteron quadrupole coupling constant from the deuteron magnetic resonance spectrum of the same sample. The value was found to be 172.5 ± 1.5 KHz. The value of the quadrupole coupling constant is in agreement with that obtained for the deuteron bonded to $sp^3$-hybridized carbon. (BBB)

**13868** ISOTOPE EFFECTS ON METASTABLE TRANSITIONS. IV. ISOTOPIC METHANOLS. Lifshitz, Chava; Shapiro, M.; Sternberg, Rachel (Hebrew Univ., Jerusalem). Israel J. Chem.; 7: 391-403(1969).

Metastable transitions were studied in the mass spectra of methanol and deuterated methanols in a sector mass spectrometer. The relative abundances of the various metastable ions at 70 eV were determined. The intensities were in good agreement with those obtained employing a double-focussing instrument operating in the metastable mode. A strong isotope effect on the intensity of the anomalous parent-ion metastable transition was observed. This transition and the one leading to a "flat top" metastable peak were studied. Appearance potentials were determined for the ions involved, by the retarding potential difference method, and for the metastables themselves by conventional techniques. Metastable ion decay curves were obtained using an improved pulsed ion source. The reaction responsible for the major fragment-ion (flat-topped) metastable transition (i.e., $CH_3OH^+ \rightarrow CHO^+$) was shown to involve a molecular hydrogen elimination. Only minor isotope effects were observed on the intensities and decay rate constants of this reaction upon deuteration. No conclusive evidence could be found to show that the precursor ion of this reaction ($CH_3OH^+$) was electronically excited. The observations could however be explained within the framework of the quasi-equilibrium theory. (BBB)

# Radiation and Nuclear Chemistry

*Refer also to abstracts 13732, 13777, 13857, 13988, 14029, 14182, 15734, and 16005.*

**13869** (COO-1385-30) ELECTRON SPIN RESONANCE STUDIES OF RADIATION EFFECTS. Technical [Progress] Report, January 1, 1969–December 31, 1969. Rogers, Max T. (Michigan State Univ., East Lansing. Dept. of Chemistry). Contract AT(11-1)-1385. 7p. Dep. CFSTI.

The $\dot{C}H_2-\underset{CH_3}{\overset{CH_3}{\underset{|}{\overset{|}{C}}}}-CONH_2$ radical was observed in the ESR spectrum of trimethylacetamide γ-irradiated at 77 K. ESR spectral studies on monocrystalline sec-butyramide, γ-irradiated at 77 K, indicated the existence of the $\dot{C}H_2-\underset{CH_3}{\underset{|}{CH}}-CONH_2$ radical. Radicals formed in the irradiation at 77°K of the ammonium salts of monofluoroacetic acid and difluoroacetic acid are being evaluated. (J.G.B.)

**13870** (COO-1385-31) ESR STUDY OF IRRADIATED SINGLE CRYSTALS OF ACETAMIDINE HYDROCHLORIDE. Watson, J. C.; Rogers, Max T. (Michigan State Univ., East Lansing. Dept. of Chemistry). [1969]. 11p. Dep. CFSTI.

Two radicals were identified in γ-irradiated single crystals of acetamidine hydrochloride. Material irradiated and observed at 77°K shows only the ESR spectrum characteristic of the V center $Cl_2^-$. On warming to 125°K the spectrum of the V center was replaced by that of a new radical which showed hyperfine interaction with two equivalent α protons plus weaker interaction with two more distant protons. This second radical is believed to be $[\cdot CH_2C(NH_2)_2]^+$ formed by abstraction of a methyl hydrogen of an undamaged acetamidinium ion by the hole center. The g and A(Cl) tensors for $Cl_2^-$ and the hydrogen hyperfine splitting tensor A(H) for the second radical are reported and discussed. (auth)

**13871** (COO-1385-32) V CENTERS AND HYDROGEN ATOMS IN IRRADIATED HYDRAZINIUM DIHALIDES. Rogers, M. T.; Watson, J. C. (Michigan State Univ., East Lansing. Dept. of Chemistry). [1969]. 8p. Dep. CFSTI.

Results are reported on ESR spectral studies of $Cl_2^-$ in γ-irradiated single crystals of hydrazinium dichloride, $N_2H_4Cl_2$, and of $Br_2^-$ in hydrazinium dibromide, both at 77°K. Hydrogen atoms rather than $F_2^-$ were observed in hydrazinium difluoride irradiated at 77°K with 1-MeV electrons. (J.G.B.)

**13872** (COO-1620-4) CHEMICAL EFFECTS OF THE NUCLEAR REACTION $^{14}N(n,p)^{14}C$ IN VARIOUS NITROGENOUS COMPOUNDS. Progress Report, May 1, 1969–April 30, 1970. Vaughan, John D. (Colorado State Univ., Fort Collins. Dept. of Chemistry). 15 Jan 1970. Contract AT(11-1)-1620. 15p. Dep. CFSTI.

The chemistry of recoil carbon-14 produced by pile irradiation of crystalline compounds containing nitrogen was studied. Two methods of target dissolution were used in experiments with $KN_3$. In the first, target samples with or without post-irradiation treatment were dissolved in water. In the second, target samples were heated and held at 400°C for 2 to 3 hours, leading initially to melting and subsequently to decomposition of $KN_3$. Distribution of activity among the products is tabulated. The protective role of carriers in the melt is noted. (J.G.B.)

**13873** (KFK-1067) DEPENDENCY OF THE CHEMICAL BEHAVIOUR OF MOLYBDENUM RECOIL ATOMS IN METAL CARBONYLS ON THE ENERGY AND THE ISOTOPE. Henrich, E.; Wolf, G. K. (Heidelberg Univ. (West Germany). Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Heisse Chemie). Oct 1969. 19p. (CONF-690924-2). Dep. CFSTI (U. S. Sales Only).

From International Conference on the Use of Cyclotrons in Chemistry, Metallurgy, and Biology, Oxford, England.

Different isotopes recoiling from nuclear reactions sometimes show a difference in their chemical behavior. With the view of studying the causes for this difference target elements ranging from molybdenum to indium were irradiated in close contact with $Cr(CO)_6$ with 600-MeV protons. The $^{99}Mo$ and $^{93m}Mo$ recoil atoms having energies dependent on the mass difference between target and product reacted with the $Cr(CO)_6$ forming $Mo(CO)_6$. The yield of this reaction was determined in relation to the individual isotopes and their recoil energy. Further $Mo(CO)_6$ was irradiated with 600-MeV protons, fast neutrons, and thermal neutrons. The percentage of $^{99}Mo$, $^{93m}Mo$, and $^{99}Mo$ having the configuration of the target (retention) was analyzed in relation to the individual isotopes and the irradiation conditions. It was found in all cases that the retention of $^{93}Mo$ was higher than that of $^{99}Mo$ and $^{99}Mo$. The magnitude of this isotope effect was independent of the recoil energy and the irradiation conditions. The existence or nonexistence of nuclear levels with sufficient lifetime ($>10^{-12}$ sec) in the deexcitation cascade of the excited recoiling isotopes is quoted as cause for their different chemical behavior. (auth)

**13874** (ORNL-4400) REACTOR CHEMISTRY DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1968. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 174p. Dep. CFSTI.

Progress is reported on: chemical studies of molten salt systems, behavior of fission products and protactinium in molten fluorides, corrosion and chemical behavior in reactor and desalination environments, electric conductance of aqueous electrolytes at 800°C and 4000 bars, physical chemistry of high-temperature aqueous solutions, diffusion processes, irradiation behavior of high-temperature fuel materials, nuclear safety tests in major facilities, aerosol behavior, behavior of elemental and combined iodine, special nuclear safety studies, effects of neutron irradiation on refractory materials, effects of radiation on organic materials, and surface chemistry. An abstract was prepared for each of the 14 sections. (M.C.G.)

*For abstracts of individual sections see: 13799–13804, 13875, 13998, 13999, 14646, 14967, 14968, 16217, and 16218.*

**13875** (ORNL–4400, pp 151-7) EFFECTS OF RADIATION ON ORGANIC MATERIALS. (Oak Ridge National Lab., Tenn.).

Research is reported on: trapped electrons in γ-irradiated polymers, radioinduced reactions of hydrocarbons, addition reactions of furan derivatives, development of radiation-resistant insulators, and the radiation chemistry of the registration of particle tracks in plastics. (M.C.G.)

**13876** (RPI–3821-4) PULSE RADIOLYSIS OF GASES: $N_2$–NO AND He–$N_2$ SYSTEMS. Rushbrook, P.; Dondes, S.; Harteck, P. (Rensselaer Polytechnic Inst., Troy, N. Y.). 15 Jan 1970. Contract AT(30-3)-3821. 196p. Dep. CFSTI.

The pulse radiolysis technique was applied to gas mixtures of nitrogen–nitric oxide and helium–nitrogen. The source of radiation was a pulsed 1-MeV Van de Graaff electron accelerator with a power output of 0.5 joules per pulse, and a pulse width of $0.5 \times 10^{-6}$ seconds. The primary band systems that appeared in the gross spectra of many of the mixtures were the NO(γ), $N_2$ 2nd positive and $N_2^+$ 1st negative systems. Other bands and lines also appeared, which were due to minute impurities in the mixtures. The specific band systems studied in both gas mixtures, with the available instrumentation, were the NO(γ) and the NH 3360 Å systems. Both were persistent bands, and appeared under a wide range of conditions. All the observed decays followed first order kinetics: the half-lives varied inversely with the NO concentration in the $N_2$–NO mixtures and inversely with the nitrogen concentration in the He–$N_2$ mixtures. The reaction was determined to be an energy transfer between the Vegard–Kaplan state of nitrogen and the ground state of nitric oxide. The lifetime of the NH* formation was also measured in the same mixtures as the NO* formation. The similar lifetime and concentration dependency led to the conclusion that the formation of the NH* is also by an energy transfer process between nitrogen in the Vegard–Kaplan state and NH in the ground state. A sequential irradiation of a mixture of nitrogen and 0.64% nitric oxide indicated a $-G_{NO} = 3.00$, in good agreement with published values. Over relatively short periods of time, no $NO_2$ was observed in the gas phase, but rather, migrated to the walls of the reaction vessel and formed a condensation product, $2HNO_3 \cdot N_2O_5$. Nitrous oxide and oxygen were ultimately produced as final products on the decomposition of the condensation product. The nitric oxide decomposed to an equilibrium concentration of a few hundred ppM, and on long term irradiation, the oxygen and nitrous oxide also tended to approach an equilibrium concentration. The formation lifetimes of the other observed emissions were too short to be measured. (M.C.G.)

**13877** (RRL–2310-287) QUARTERLY REPORT [ON RADIATION RESEARCH], OCTOBER 1, 1969–DECEMBER 31, 1969. Fundamental Research No. 6041. (Mellon Inst., Pittsburgh, Pa. Radiation Research Labs.). 12 Jan 1970. 14p. Dep. CFSTI.

Progress is reported on: a steady-state method for measuring electron reaction rates, electron reactions in the gas phase, positive ion reactions of cyclopropane, effects of electron scavengers on the γ radiolysis of 2,2-dimethylbutane and 2,2,4-trimethylpentane, the thermal hydrogen atom yield in the γ radiolysis of isooctane, ESR studies in $SF_6$ matrices, spin resonance studies of alcohols during radiolysis, electron trapping in the crystalline state of heterocyclic compounds with large dipole moments, radiation scavenging in aqueous solutions, solvent effects on the stabilities of Meisenheimer complexes, and micellar effects on the base-catalyzed formation of nitroform from tetranitromethane. (M.C.G.)

**13878** (STI/PUB–236) LARGE RADIATION SOURCES FOR INDUSTRIAL PROCESSES. Proceedings Series. Proceedings of a Symposium Held in Munich, 18–22 August 1969. (International Atomic Energy Agency, Vienna (Austria)). Dec 1969. 705p. (In several languages). (CONF-690805). IAEA $19.00.

Forty-eight papers presented at the symposium are included. Separate abstracts were prepared for 42 papers. The remaining 6 papers were previously abstracted for NSA. See abstracts 23: 35517, 39068, 43335, 45306, and 48698 and 24: 09976. (M.C.G.)

*For abstracts of individual papers see: 13912–13946, 14186, 14320–14322, and 15733–15735.*

**13879** (UCRL–18887) CHEMICAL BIODYNAMICS ANNUAL REPORT, 1968. (California Univ., Berkeley. Lawrence Radiation Lab.). June 1, 1969. Contract W-7405-eng-48. 140p. Dep. CFSTI.

Four sections are included; separate abstracts were prepared for two. The remaining two sections contain information on plant biochemistry and animal and bacterial biochemistry. (P.C.H.)

*For abstracts of individual sections see: 13812 and 13880.*

**13880** (UCRL–18887, pp 57-87) RADIATION CHEMISTRY, PHOTOCHEMISTRY, CHEMICAL EVOLUTION. (California Univ., Berkeley. Lawrence Radiation Lab.).

Developments are reported for studies on: role of trapped electrons in the radiolysis of choline chloride; and identification of the unknown compound "U-2" from the $^{14}C$-benzene reaction. Studies were made on choline chloride in order to find whether thermal activation could be responsible for either diffusion of radicals or release of trapped electrons from sites that are populated with electrons during γ irradiation. Attempts were made to identify the U-2 compound under the assumption that U-2 is a 7-carbon compound. (P.C.H.)

**13881** RADIOLYSIS OF p-NITROSODIMETHYLANILINE IN AQUEOUS SOLUTIONS. Shah, Shirish Kalyaubhai. Newark, Del.; Univ. of Deleware (1968). 185p.

Thesis.

In the past, the dependence of G(solute) and G(product) on the low solute concentration was attributed to impurities, back reaction of radicals, or complex reaction mechanisms in the radiolysis of aqueous solutions. G(-RNO), the radiolytic yield for the destruction of p-nitrosodimethylaniline, was studied as a function of RNO concentration, oxygen concentration, added solute concentration, pH, and radiation intensity. The behavior of RNO at low solute concentration appears to be different than expected from the point of view of the "Classical" theory of aqueous radiation chemistry. An alternative reaction mechanism, which may account for the experimental results is suggested. A unimolecular decay of X and Y was postulated where X and Y may be electronically excited molecules. It is assumed that RNO reacts with X and Y at a diffusion controlled-rate. The life times of $X = 8 \times 10^{-7}$ sec and $Y = 1 \times 10^{-4}$ sec were estimated. The relative rate constants of methylene blue, p-nitrodimethylaniline, oxygen, and $Cu^{2+}$ in comparison with RNO for X and Y were calculated. The effects of oxygen, $Cu^{+2}$, methylene blue, and p-nitrodimethylaniline on G(-RNO) indicate the possibility of energy transfer reactions. The effects of ethanol, $I^-$, $Br^-$, and $NO_3^-$, on G(-RNO) indicate competition kinetics for hydroxyl radicals. The relative rate constants obtained are in fair agreement with the reported values. With the assumption of simple competition kinetics the calculations for $G_{\cdot OH}$ were carried out at different RNO concentrations. From these calculations it appears that $G_{\cdot OH}$ depends on RNO concentration and that it is much lower than the standard reported values of $G_{\cdot OH=2.2-2.9}$. Some interesting results were obtained in aqueous methylene blue -RNO solutions. Both the solutes were able to protect each other from radiolytic destruction under certain conditions. The methylene blue was able to reduce G(-RNO) by 1 even when RNO was 100 times higher in concentration. $G(H_2O_2)$ appears to behave in a very similar fashion to that of G(-RNO) as a function of RNO concentration in air-saturated and oxygen-saturated solutions. It was concluded that two primary reactive intermediates are involved in the radiolysis of aqueous solutions of RNO. (Disser. Abstr.)

**13882** RADIATION TREATMENT TO RENDER POLYESTERS SUSCEPTIBLE TO PERMANENT RETENTION OF DYES. Das Gupta, S. Canadian Patent 826,637. 4 Nov 1969.

A process is described for improving the ability of polyesters to accept a dye. It consists of exposing the polyester in contact with a grafting solution to γ radiation at a dose rate of $5 \times 10^4$ to $2 \times 10^6$ rad/hr for a total dose of 1 to 15 megarads. The grafting solution is a polymerizable monomer selected from vinyl monomers containing a hydrophilic end group and vinylidene monomers containing a hydrophilic end group in a solvent of methanol, ethanol, or a mixture of the two. (F.S.A.)

**13883** MODIFICATION OF GLASS FIBER SURFACES BY THE RADIATION–CHEMICAL METHOD. Klimanova, R. S.; Sergeeva, V. K.; Serenkov, V. I. Plast. Massy; No. 5, 33-5(1968). (In Russian).

Radiation-chemical polymerization of styrene to the surface of glass fibers to increase their adhesion to polyester resins was investigated. Degreased glass fibers T-90 were submerged in styrene monomer in glass ampoules and subjected to γ irradiation at 20°C. The degree of grafting was determined from ir spectra in the 2000 to 4000 $cm^{-1}$ range and gravimetrically. Styrene grafted on the glass fiber only during γ irradiation; no styrene grafted on the glass without γ irradiation, or after only preliminary irradiation of the glass. Extent of grafting depended on dosage and radiation power: 55 rad/sec irradiation (15, 55, 110, and 150 rad/sec were investigated) gave the highest degree of grafting for most dosages tested. The adhesion of polyester binder PN-1 to the styrene-modified glass fiber was investigated. Adhesion of PN-1 to glass fiber was significantly increased by the styrene modification: 0.1% graft increased adhesion twofold; with 0.34% grafting, cohesive rupture occurred at 114 $kgs/cm^2$ loading. Strength of the

modified fiberglass did not change after 2 hr boiling in water. Water adsorption of the fiberglass increased and strength after boiling in water decreased with increasing amount of polystyrene on the glass fiber surface. (JPRS)

**13884** VIBRATIONAL STRUCTURE IN THE ELECTRONIC ABSORPTION SPECTRUM OF THE TRAPPED ELECTRON IN CRYSTALLINE ACETONITRILE-$d_3$ AT 77°K. Holloman, Lynn; Sprague, Estel D.; Williams, Ffrancon (Univ. of Tennessee, Knoxville). Contract AT(40-1)-2968. J. Amer. Chem. Soc.; 92: 429-30(28 Jan 1970). (ORO-2968-50).

The existence of vibrational fine structure in the optical absorption spectrum of a trapped electron in molecular crystals of acetonitrile-$d_3$ is reported. Previously reported ESR studies indicate that trapped electrons are produced in samples of crystalline acetonitrile-$d_3$ by $\gamma$-irradiation at 77°K. The presence of a trapped electron in $\gamma$-irradiated acetonitrile-$d_3$ is indicated also by an optical absorption with $\lambda_{max}$ at 510 nm. That the ESR and optical absorption spectra refer to the same center has now been proved by experiments showing that the optical spectrum is also restored thermally after photobleaching without any loss of intensity for the complete cycle. (J.G.B.)

**13885** RADIATION-INDUCED GAS PHASE GRAFT COPOLYMERIZATION OF BUTADIENE TO POLY(VINYL CHLORIDE). 1. THE KINETICS OF GRAFT COPOLYMERIZATION. Morishima, Yotaro; Harayama, Hiroshi (Sekisui Chemical Co., Osaka). Kobunshi Kagaku; 26: 689-95(Oct 1969). (In Japanese).

Gas-phase graft copolymerization of butadiene (BD) to poly(vinyl chloride) (PVC) powder induced by $\gamma$ radiation at 60°C was studied. The grafting was carried out under 760 mm Hg vapor pressure of BD. The rate of grafting decreased with reaction time except the initial stage of polymerization. The "post-grafting" was more remarkable when the irradiation was stopped at the earlier stage of the polymerization. Though BD gas contained ~5 vol % of oxygen, the polymerization was not impeded. The degree of dehydrochlorination that occurred during the graft copolymerization was less than 1:20000 in comparison with PVC irradiated in a nitrogen atmosphere instead of BD under the same condition. Most grafting occurred uniformly in the solid phase of PVC powder. Furthermore, it is deduced from kinetic studies of the polymerization that the propagation reaction is not controlled by the diffusion of monomer, but the termination is extremely suppressed. (NSA of Japan)

**13886** RADIATION-INDUCED GAS PHASE GRAFT COPOLYMERIZATION OF BUTADIENE TO POLY(VINYL CHLORIDE). 2. THE EFFECTS OF GRAFT COPOLYMERIZATION TEMPERATURE. Harayama, Hiroshi; Morishima, Yotaro (Sekisui Chemical Co., Osaka). Kobunshi Kagaku; 26: 695-700(Oct 1969). (In Japanese).

The effects of reaction temperature on the $\gamma$-induced gas-phase grafting of butadiene (BD) to poly(vinyl chloride) (PVC) were studied. Arrhenius plots, concerning the rate of grafting, gave straight lines with slope changes at 50°C. It was suggested that the change of grafting mechanism occurred at this temperature. Viscoelastic properties of the graft copolymers molded by a mixing roll and a hot press showed that the dispersed particle-size of grafted BD constituent became smaller with increasing grafting temperature. This agreed well with electron microscopic observations. Dynamic loss ($E''$) of both PVC and graft copolymer increased at about 50°C with the increasing temperature. From the above results, it is assumed that the change of physical properties of the solid phase, in which graft copolymerization occurs, affects strongly the graft copolymerization reaction. (NSA of Japan)

**13887** CHARGE AND ENERGY DISTRIBUTION OF RECOIL ATOMS FROM THE ALPHA DECAY OF $^{226}$Th. Gunter, Karlene Corbit Klages. Berkeley, Calif.; Univ. of California (1968). 209p.

Thesis.

The charge and energy distribution of $^{226}$Th recoils from thin, electrostatically collected recoil sources were studied with a 180 deg double focussing alpha spectrograph. It was determined that the energy distributions so obtained were the result of collisions between the recoils and atoms on or in the source plate. The charge distribution of the recoils associated with $^{226}$Th$\alpha_0$ peaked at a charge of +1 whereas those associated with the electron conversion process following the emission of a $^{226}$Th$\alpha_{111}$ peaked at a charge of +11. These charge distributions are likely not too different from those which would be obtained from the decay of gaseous $^{226}$Th. In order to ensure that the recoils sources used for the above study were thin, a series of experiments was carried out to determine the best method of preparing consistently thin alpha sources. Three techniques were investigated: vacuum sublimation, electrostatic parallel plate collection and cylindrical electrostatic collection of a thin edge. Of these three, parallel plate collection produced the thinnest sources by far. The best such plates were made by collecting recoils in air at STP onto clean Pt employing the smallest possible source-collector separation and the minimum electric field intensity needed for total collection. In connection with this work, more accurate values were obtained for the intensities of the various alpha groups of $^{226}$Th than are presently in use. The intensity of the 111.1 keV $\gamma$ ray was also obtained along with evidence that the present level assignments for the third and fourth excited states of $^{222}$Ra are correct. (Disser. Abstr.)

**13888** RADIATION-CHEMICAL TRANSFORMATIONS OF ATOMS OF PHOSPHORUS IN KCl MONOCRYSTALS. Bogdanov, R. V.; Murin, A. N.; Olevskii, E. B. Radiokhimiya; 11: 612-14 (1969). (In Russian).

The radiation-chemical transformations of recoil phosphorus atoms in KCl were studied in relation to the intensity of the proton beam and the duration of proton bombardment. KCl monocrystals were grown in air, split into portions of 0.02 to 0.1 g, annealed 4 hours, and irradiated at room temperature by protons with an energy of 660 MeV. Formation and reactions of recoil phosphorus were studied. (M.C.G.)

**13889** DISTRIBUTION OF ATOMS OF RECOIL PHOSPHORUS ACCORDING TO VALENCE STATES IN DEFORMED ALKALI METAL HALIDE CRYSTALS. Bogdanov, R. V.; Olevskii, E. B. Radiokhimiya; 11: 616-17(1969). (In Russian).

An attempt was made to show interdependence between dislocations in the structure of crystals and the relative content of different valence states of recoil phosphorus atoms. NaCl and KCl crystals were grown, split into forms with a weight of 0.1 to 0.2 g, and annealed for 20 hr in a current of purified argon at 770 and 730°C, respectively. The number of dislocations was determined by etching. The crystals were then irradiated by 660-MeV protons for 2.5 hr with a beam intensity of $1.4 \times 10^8$ protons/cm$^2$/sec. Chemical analyses for radioactive phosphorus were carried out at pH = 3. The small oxidizing effect, which can be observed from the data tables, can be explained by the ordering of the crystalline lattice around the phosphorus atom, violated during recoil, and by reduction in the cubic symmetry of the crystal. (M.C.G.)

**13890** THE EFFECT OF $S^{2-}$ IONS ON THE CHEMICAL STATE OF RECOIL PHOSPHORUS IN KCl. Bogdanov, R. V.; Olevskii, E. B. Radiokhimiya; 11: 617-18(1969). (In Russian).

The distribution of atoms of recoil phosphorus according to the valence states was studied in crystals with a divalent impurity in the anionic sublattice. In such crystals the concentrations of anionic and cationic vacancies are changed. Monocrystals of KCl with additions of 0.5 M % $K_2S$ were chosen for the experiments. The addition of $S^{2-}$ ions caused significant oxidation of the recoil phosphorus. (M.C.G.)

**13891** SEPARATION OF ALKALINE EARTH ELEMENTS BY FOCUSING ION EXCHANGE. Shvedov, V. P.; Fomin, V. V. Radiokhimiya; 11: 565-8(1969). (In Russian).

The possibility of separation of carrier-free $^{45}$Ca, $^{89}$Sr, and $^{133}$Ba by the method of focusing ion exchange was investigated. Optimum conditions were found to be 6 min, an electric field of 32 V/cm, and 0.3 M HTA + 0.3 M $CH_3COONa$ as the catholyte and 0.1 M HCl as the anolyte. The possibility of separation of small quantities of strontium from large quantities of calcium was established. (M.C.G.)

**13892** SOLID STATE EXCHANGE AND ANNEALING OF RECOIL DAMAGE IN METAL CHELATES. Ramshesh, V. (Bhabha Atomic Research Centre, Bombay). J. Inorg. Nucl. Chem.; 31: 3878-81(Dec 1969).

Solid state exchange was studied in the systems $^{51}Cr^{3+}$/$Co(AcAc)_3$; $^{51}Cr^{3+}$/$Cr(AcAc)_3$ and $^{57}Co^{2+}$/$Al(AcAc)_3$; $^{57}Co^{2+}$/$Mn(AcAc)_3$; $^{57}Co^{2+}$/$Cr(AcAc)_3$ where AcAc = acetylacetone. Except in manganese and cobalt complexes the exchanges were found to be only 2 to 3 per cent even on heating to temperatures up to 120°C in air or in vacuum. The solid state exchange found in the $Cr^{3+}$/$Co(AcAc)_3$ system increased slightly on heating in air and more on heating in vacuum, while that of $^{*}Co^{2+}$/$Mn$/$(AcAc)_3$ increased from an initial value of 27 to 83% at 25°C. The annealing of $^{58}Co^{2+}$ recoils in nickel(II) tris-bipyridyl chloride hexahydrate and solid state exchange of $^{57}Co^{2+}$ in this complex were studied. The exchange was 2% and unchanged by heating, the initial retention in the neutron irradiated material being 14% increasing to 16% on annealing for 9 hrs at 110°C. (UK)

**13893** USING SENSITIZED REACTIONS FOR THE DETERMINATION OF RADIATION YIELDS OFELECTRONICALLY EXCITED STATES. Krongauz, V. A. (Karpov Physico-Chemical

Inst., Moscow). Int. J. Radiat. Phys. Chem.; 1: 465-78(Nov 1969). (In Russian).

The radiolytic decomposition of diacyl peroxides, azo compounds and bisulphides in aromatic solvents (benzene, toluene) was previously examined and it was shown that the decomposition of these solutes is sensitized by solvent–solute energy transfer. Stern–Volmer constants of the energy transfer for all the aromatic-substituted compounds examined were approximately equal and were found to be $\approx 5 \times 10^2$ l/mol. Maximum G-values, attained when the energy transfer was total, increase in the order: azo-compounds–bisulphides–peroxides. A comparison was made of the radiolysis, photolysis, $\gamma$- and photoluminescence of three-component solutions with two energy acceptors, one chemically decomposing (benzoyl peroxide), and the other a scintillator (PPO or p-terphenyl). The decrease of the quantum yield of sensitized benzoyl peroxide decomposition in the presence of a scintillator, and the quenching of the sensitized scintillator luminescence by peroxide, were explained in terms of a competition between the two energy acceptors as the energy transferred from the solvent. Comparison of the kinetic behaviour of the solutions on $\gamma$- and photo–irradiation indicates that energy transfer occurs from the excited molecules of the solvent in the first singlet (flourescent) state. It was shown that benzene photosensitized trans-cis-isomerization of stilbene is a result of triplet–triplet energy transfer from the solvent. On $\gamma$-irradiation of benzene solutions this process is interfered with by the isomerization caused by radicals produced by the irradiation of the solvent. The benzene-photosensitized o-nitrobenzaldehyde rearrangement into o-nitrobenzoic acid is caused by triplet–triplet energy transfer at concentrations $< 2 \times 10^{-4}$ mol/l and by singlet–singlet energy transfer at higher concentrations. This was demonstrated by comparing the concentration dependence of the photosensitized aldehyde rearrangement with that of the benzene fluorescence quenching by aldehyde. A similar concentration dependence was found for radiolytic rearrangement of the aldehyde in solution. The sensitized reactions described were used to estimate the G-values of the solvent molecules in fluorescent and triplet excited states. For benzene these G-values were found to be $\approx 0.4$ molecules respectively per 100 eV of energy absorbed. (auth) (UK)

**13894** EFFECT OF THE NATURE OF THE SOLID ON THE DEGREE OF RADIATION-CHEMICAL TRANSFORMATION OF ADSORBED PARA-AMINOAZOBENZENE. Doroshenko, V. N.; Verkhgradskii, O. P.; Chervetsova, I. N. Khim. Vys. Energ.; 3: 466-7(Sep-Oct 1969). (In Russian).

The effect of the nature of the solid on radiation-chemical transformations of p-aminoazobenzene adsorbed on plates of Al, Cu, Pb, Au, and quartz was studied. It was established that the dose rate, orientation of the plate in the radiation field, and surrounding medium did not have an effect on the degree of transformation of adsorbed p-aminoazobenzene, but the change in concentration of dye in solution obtained by elution from the surface after irradiation was proportional to dose. (M.C.G.)

**13895** ESR EVIDENCE FOR $O_2^-$ AS A LONG-LIVED TRANSIENT IN IRRADIATED OXYGENATED ALKALINE AQUEOUS SOLUTIONS. Nilsson, Robert; Pick, Francis M.; Bray, Robert C.; Fielden, Martin (Inst. of Cancer Research, London. Royal Cancer Hospital, London). Acta Chem. Scand.; 23: 2554-6(1969).

By combining pulse radiolysis and rapid-freezing ESR technique clear evidence is obtained for the presence of a paramagnetic species, identical with $O_2^-$, in oxygen-saturated aqueous solutions of $\sim 10^{-3}$ M $Ba(OH)_2$ several hundred milliseconds after irradiation at about 20°C with 4-MeV electrons. (Denmark)

**13896** ZUR STRAHLENCHEMISCH INDUZIERTEN PYROLYSE GESAETTIGTER KOHLENWASSERSTOFFE. (Radiation-Chemical-Induced Pyrolysis of Saturated Hydrocarbons). Meder, Werner. Goettingen, Ger.; Georg-August-Univ. Goettingen (1969). 217p. Thesis.

The simultaneous effects of ionizing radiation and thermal energy on saturated hydrocarbons are designated as radioinduced cracking. An electron generator and $^{60}Co$ were used as radiation sources. It was found that the radioinduced cracking is characterized by initiation of radical chain reactions; the activation energy for the propagation reaction was in the region of 20 kcal/mole. Below the boundary temperature for cracking, hydrogen was the chief product, but above this temperature formation of lower hydrocarbons was most important. (M.C.G.)

**13897** CHEMICAL DOSIMETRY WITH DOPED POLY(HALOSTYRENE) FILM. Harrah, L. A. (Sandia Labs., Albuquerque, N. Mex.). Radiat. Res.; 41: 229-46(Feb 1970).

Thin films of poly(halostyrenes) doped with malachite green methoxide were found to be effective chemical dosimeters for dose rates to $10^{11}$ rads/sec and cover the range in dose from $5 \times 10^4$ to $1.5 \times 10^7$ rads. These materials form a stable distribution image of the radiation traversing the film and are particularly useful in connection with experiments using pulsed electron beam machines. From studies on the rate of appearance of color following exposure and on the molecular emission from solutions of leuco malachite greens, a metastable intermediate is found in the radiation and photochemical dissociation reaction. The radiation chemical sequence of events is summarized, and the leuco malachite greens are shown to be efficient energy scavengers in poly(halostyrene) hosts. (auth)

**13898** $^{60}Co$ GAMMA-RADIOLYSIS OF LIQUID FORMAMIDE: GASEOUS AND HIGH-BOILING STABLE PRODUCTS. Matsumoto, Akira; Hayashi, Nobuyoshi; Lichtin, Norman N. (Boston Univ.). Radiat. Res.; 41: 299-311(Feb 1970).

Yields per 100 eV of products of $^{60}Co$ gamma-radiolysis of anhydrous liquid formamide at room temperature, which are either gaseous under ordinary conditions or are less volatile than formamide, obtained with 10-Mrad dose, were $G(H_2) = 0.8_1$; $G(CO) = 0.6_1$; $G(CO_2) = 0.2$; $G(NH_3) = 0.7$; $G[(CONH_2)_2] = 0.2$; $G[(HCONH)_2] = 0.04$; $G(C_4H_8N_2O) = 0.06$; polymer, mol wt 1655, G = 0.006; and G(HCN), trace. $G(NH_3)$ and G(HCN) decreased sharply with increasing dose amounting to 2.6 and 0.3 molecules/100 eV, respectively, with a dose of 0.16 Mrad. $G(CO_2)$ is similarly dose dependent, but $G(H_2)$ and G(CO) are not. $N_2O$ up to concentrations of the order of $4 \times 10^{-2}$ M had little or no effect on $G(H_2)$ and G(CO), although substantial amounts of $N_2$ were produced. Water at concentrations up to 0.1 M did not influence $G(H_2)$, G(CO), or $G(CO_2)$ significantly. The isotopic composition of hydrogen produced by radiolysis of $HCOND_2$ in the liquid and solid states indicated selective detachment from carbon. Selectivity is more pronounced in the solid state. The chemical significance of the data is discussed. (auth)

**13899** A SPECTROSCOPIC STUDY OF THE ALPHA-RAY-INDUCED LUMINESCENCE IN GASES; THE HELIUM–CARBON MONOXIDE SYSTEM. Kunz, C.; Dondes, S.; Harteck, P. (Rensselaer Polytechnic Inst., Troy, N. Y.). Contracts AT(30-3)-321; AT(30-1)-3816. Radiat. Res.; 41: 288-98(Feb 1970).

A spectroscopic study was made of luminescence produced by the polonium-210 alpha irradiation of helium at atmospheric pressure containing small quantities of carbon monoxide (from $3 \times 10^{-5}$% to 1%). Spectrograms were taken covering the range from 2400 Å to 12,000 Å; with and without the application of an electric field to the luminescent gas; and at liquid nitrogen as well as room temperatures. Emissions from excited C, O, $C_2$, CO, $CO^+$, and $CO_2^+$ were observed. The most intense emissions are due predominately to the ion-neutral reaction of $(He)_2^+$ with CO. Additional reactions pertinent to the system are examined. (auth)

**13900** RADIATION-CHEMICAL BEHAVIOR OF RECOIL PHOSPHORUS ATOMS IN POTASSIUM CHLORIDE MONOCRYSTALS. Bogdanov, R. V.; Olevskii, E. B.; Tamonov, A. A. (Leningrad State Univ.). Khim. Vys. Energ.; 3: 394-400(Sep-Oct 1969). (In Russian).

The increase in the content of trivalent forms of $^{32}P$ in KCl crystals, during proton bombardment, shows that the oxidation of recoil atoms proceeds only in the initial stage of irradiation. The agents most probably responsible for oxidation are electron holes. The photochemical reduction of atoms of radiophosphorus occurs with varying efficiency in relation to the degree of f-electron escape through defects in the crystalline lattice. (tr-auth)

**13901** RADIATION-CHEMICAL SYNTHESIS OF ORGANIC NITROGEN COMPOUNDS. Podkhalyuzin, A. T.; Trishkin, A. E.; Vereshchinskii, I. V. (Inst. of Physical Chemistry, Moscow). Khim. Vys. Energ.; 3: 401-7(Sep-Oct 1969). (In Russian).

The radiation-chemical fixation of molecular nitrogen by the action of accelerated electrons or $^{60}Co$ gamma radiation on a mixture of nitrogen with hydrocarbons was studied. The effects of the ratios of reacting components, pressure, and temperature on the yield of nitrogenous products were determined. The kinetics of accumulation of hydrocyanic acid and acetonitrile in the gas phase were studied by photocolorimetry and gas-liquid chromatography. Mechanisms of the reactions are discussed. (tr-auth)

**13902** CONDUCTIVITY INDUCED BY ELECTRON IRRADIATION IN SOLID NAPHTHACENE. THE EFFECT OF A MAGNETIC FIELD. Yakovlev, B. S.; Novikova, L. I.; Frankevich, E. L. (Inst. of Chemical Physics, Moscow). Khim. Vys. Energ.; 3: 408-12(Sep-Oct 1969). (In Russian).

For investigation of excitons generated by ionizing radiation, a method was used that is based on the effect of a magnetic field on the photoconductivity of molecular crystals. The effect of a magnetic field on the stationary electric conductivity of films of crystalline naphthacene, induced by electron bombardment at 3 to 12 keV, was studied. It is shown that the magnetic field, at a potential

of 1 kV, causes an increase in conductivity of about 1%. Results indicated that the formation of free charges on electron bombardment of naphthacene occurs basically as a result of dissociation of excitons. The radiation yield of triplet excitons was significantly below the yield of singlet excitons. (tr-auth)

**13903** IRREGULARITY OF DISTRIBUTION OF STABILIZED H ATOMS IN IRRADIATED CHILLED AQUEOUS SOLUTIONS OF ACIDS. Belevskii, V. N.; Zador, E.; Bugaenko, L. T.; Golubev, V. B. (Moscow State Univ.). Khim. Vys. Energ.; 3: 421-6 (Sep-Oct 1969). (In Russian).

In perchloric acid matrices irradiated at −196°C by gamma radiation and alpha particles, the relation of the line width of the electron paramagnetic resonance spectra of the stabilized H atoms to their concentration, the concentration of the acid, and the isotopic composition of the water was determined. It was found that the line width of H atoms increases with increases in their concentration and decreases with increasing concentration of the acid and with increasing deuterium fraction in the water. The data obtained indicated an inhomogeneous distribution of H atoms in the matrix volume. (tr-auth)

**13904** INVESTIGATION OF THE RADIOLYSIS OF ETHYLENE–PROPYLENE RUBBER. Kim, I. P.; Egorov, E. V.; Barkalov, I. M.; Dogadkin, B. A.; Tarasova, E. N. (Inst. of Chemical Physics, Moscow). Khim. Vys. Energ.; 3: 427-32(Sep-Oct 1969). (In Russian).

The processes of joining, decomposition, gas evolution, and formation of free radicals and double bonds on irradiation of ethylene–propylene rubbers of different molecular weights by gamma rays or 25-MeV electrons were studied. Conclusions were made regarding the mechanisms and kinetics of the processes. The effect of sulfur of the radiolysis was studied. (tr-auth)

**13905** RADIOLYSIS OF TETRAFLUOROETHYLENE. Barchenkova, A. I.; Baberkin, A. S.; Volkova, E. V. Khim. Vys. Energ.; 3: 433-7(Sep-Oct 1969). (In Russian).

Gas chromatography and infrared spectroscopy were used to study the gamma radiolysis of tetrafluoroethylene at pressures below atmospheric and at 18 to 20°C. The relation of product yield to absorbed dose was determined. Radiolytic products were identified and a scheme for their production based on participation of the free radical $CF_2$ is presented. (tr-auth)

**13906** INVESTIGATION OF THERMOSTIMULATED CURRENT IN POLYETHYLENE, WHICH WAS PREVIOUSLY IRRADIATED AT LOW TEMPERATURE BY $^{60}$Co GAMMA RADIATION. Sichkar, V. P.; Baisberg, S. E.; Karpov, V. L. (Inst. of Physical Chemistry, Moscow). Khim. Vys. Energ.; 3: 438-42(Sep-Oct 1969). (In Russian).

The curve of the thermostimulated current from −110 to 110°C for polyethylene of low density was studied in relation to the radiation dose, the rate of heating, and the presence of dissolved oxygen. Five maxima were discovered on the curve. One was caused by the dissolved oxygen and one by irreversible changes in the material that was irradiated to a high dose. The data obtained were interpreted on the basis of the model of electron conductivity with thermal liberation of electrons from traps in the zone of conductivity and their subsequent recombination. (tr-auth)

**13907** EFFECT OF PREVIOUS IRRADIATION ON THE THERMAL DECOMPOSITION OF AMMONIUM PERCHLORATE. Zakharov, Yu. A.; Isaev, R. N.; Nevostruev, V. A.; Vakhovskaya, L. A. (Tomsk Polytechnical Inst., USSR). Khim. Vys. Energ.; 3: 443(Sep-Oct 1969). (In Russian).

The thermal decomposition of ammonium perchlorate previously irradiated by x rays with a maximum energy of 0.18 MeV, by 5-MeV protons, or neutrons produced by the reaction $^{9}$Be(d,n)$^{10}$B, was studied. The rate of heating was 4°/min. Gaseous products from different degrees of decomposition were determined mass spectrometrically. Radiolytic products increased the thermal decomposition at low temperatures above 300°C. (M.C.G.)

**13908** PULSE RADIOLYSIS OF PYRROLIDINE. Getoff, N.; Schwoerer, F. (Max-Planck-Institut fuer Kohlenforschung, Muelheim, Ger.). Radiat. Res.; 41: 1-14(Jan 1970).

The formation, decay, and absorption spectra of transients formed from pyrrolidine in aqueous solutions were studied. The solvated electron ($e^-_{aq}$) reacted with the protonated and the nonprotonated pyrrolidine forming the $C_4H_8N\cdot$ radical. The rate constants were: $k(e^-_{aq} + C_4H_8NH_2^+) = (7.5 \pm 1.5) \times 10^6$ $M^{-1}$second$^{-1}$ and $k(e^-_{aq} + C_4H_8NH) = (1.1 \pm 0.5) \times 10^8 M^{-1}$second$^{-1}$. The $C_4H_8N\cdot$ radical had an absorption maximum at 3200 Å, $\epsilon = 510$ $M^{-1}$ cm$^{-1}$, and disappeared in a second-order reaction, $k = 3.1 \times 10^9$ $M^{-1}$ second$^{-1}$. The rate constants for the reaction of aqueous pyrrolidine with OH radicals, $k = 9.6 \times 10^9$ $M^{-1}$ second$^{-1}$ for pH 2 and $k = 1.45 \times 10^{10}$ $M^{-1}$ second$^{-1}$ for pH 8, were also determined. The pyrrolidine transients formed by these reactions have $\epsilon = 290$ $M^{-1}$ at 3200 Å and decay by a first-order reaction, $k = 3.1 \times 10^4$ sec$^{-1}$ (half-life 15 μsecond). For the explanation of the results a probable reaction mechanism is proposed. (auth)

**13909** ELECTRON SPIN RESONANCE OF IRRADIATED SINGLE CRYSTALS OF OROTIC ACID. Horan, Paul Karl; Snipes, Wallace (Univ. of California, Berkeley). Contracts W-7405-eng-48; AT(30-1)-3799. Radiat. Res.; 41: 24-38(Jan 1970).

Hydrogen abstraction from $N_{(1)}$ occurred when single crystals of orotic acid were exposed to ionizing radiation at room temperature. The stable free radical had unpaired spin density on both $N_{(1)}$ and $C_{(5)}$ of the pyrimidine ring. Hyperfine coupling to the nitrogen nucleus showed axial symmetry, with $A^N_{\parallel} = 15.0$ gauss and $A^N_{\perp} = 0$. The hydrogen bonded to $C_{(5)}$ had principal hyperfine values, in gauss, of $A^H_x = 7.3$, $A^H_y = 22.2$, and $A^H_z = 15.1$. From the hyperfine couplings, the spin densities calculated for $N_{(1)}$ and $C_{(5)}$, respectively, were 0.29 and 0.64. Principal values of the g-tensor were $g_u = 2.0059$, $g_v = 2.0052$, and $g_w = 2.0023$. The ESR analysis can be used to predict the molecular orientation in orotic acid crystals. (auth)

**13910** CONCENTRATION EFFECT ON THE RADIOLYSIS OF AQUEOUS SOLUTIONS OF PHENYLALANINE. Brodskaya, G. A.; Sharpatyi, V. A. (Inst. of Nuclear Physics, Tashkent. Inst. of Chemical Physics, Moscow). Zh. Fiz. Khim.; 43: 2390-3(Sep 1969). (In Russian).

The kinetics of the radiolytic transformation of phenylalanine in 0.001 to 0.01M solutions were studied. Product yields were determined and a 1 to 3 linear relation between concentration and product yields discovered. (M.C.G.)

**13911** RADIOCHEMICAL POLYMERIZATION OF ETHYLENE. Teoule, R.; Cuzin, B. (CEN, Grenoble, France). Radiat. Eff.; 2: 119-27(Jan 1970). (In French).

The following two-step reaction was used to obtain further information on the mechanism of gamma radiation polymerization of ethylene: First period: Initiation reaction with $10^5$ rads/hr at various temperatures (−40°C to 22°C). Second period: Propagation reaction with 225 rads/hr at 12°C. Chain radicals were produced during the first period. The dose rate during the second irradiation is inadequate to produce an appreciable number of new polymeric chains but is necessary for chain propagation. The effects of initiation reaction temperature on propagation rate and polyethylene molecular weights in the propagation reaction are described. Temperature of irradiation in the first period was found to have an important effect on the propagation G value in the second period. (auth)

**13912** RADIATION-INITIATED CHLORINATION OF 1,2-DICHLOROETHANE. Danno, A.; Abe, T.; Washino, M.; Souda, T.; Shimada, K. (Japan Atomic Energy Research Inst., Takasaki). pp 3-19 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Radiation-initiated chlorination of 1,2-dichloroethane was carried out with a batch system to study the chlorination reaction in the laboratory and also with a flow system to obtain information on its scale-up. It was found that the direct chlorination of 1,2-dichloroethane in the presence of gamma radiation takes place by a free-radical chain reaction with a high G-value of the order of $10^5$. Successive chlorination of 1,2-dichloroethane gives 1,1,2-trichloroethane, 1,1,1,2- and 1,1,2,2-tetrachloroethane, pentachloroethane, and hexachloroethane. No products other than these polychlorethanes were detected. The composition of the reaction products depends on the degree of chlorination; it is independent of the dose rate and the chlorine feed rate. A promising application of this process is to produce trichloroethylene and perchloroethylene by thermal dehydrochlorination of a mixture of tetrachloroethane and pentachloroethane. The optimum conditions for producing these compounds with high yields depend on the feed rate of 1,2-dichloroethane and chlorine gas, the dose rate and the reaction temperature. A pilot experimental facility with a 2-liter reaction vessel was completed and is now in operation. (auth)

**13913** KINETICS AND MECHANISM OF RADIATION-INDUCED SYNTHESIS OF SUBSTITUTED CHLOROOLEFINS. Horowitz, A.; Rajbenbach, L. A. (Soreq Nuclear Research Centre, Yavne, Israel). pp 21-9 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The mechanism and kinetic aspects of eight irradiation-initiated syntheses of alkyl substituted chloroethylenes were studied at 210°C. G-values of condensation products of the order of ten thousands were found upon irradiation of solutions of trans-$C_2Cl_2H_2$, $C_2Cl_3H$, and $C_2Cl_4$ in cyclohexane. These condensation products represent compounds in which one chlorine atom in the chloroethlyene solutes has been replaced by a cyclohexyl radical. The condensation reaction was found to proceed via a free-radical chain mechanism, the radiolytical formation of cyclohexyl radicals representing the chain initiation step. In the chain propagation step the cyclohexyl radicals add to the olefins followed by chlorine atom elimination from the newly formed radicals, subsequent reaction of chlorine atoms with cyclohexane resulting in the regeneration of the cyclohexyl radicals. Kinetic expressions relating the yield of condensation products with chloroolefins concentration were derived. The effect of experimental parameters such as temperature, solute concentration, dose rate, and total dose in the condensation products yields is discussed. (auth)

**13914** GAMMA-INDUCED TELOMERIZATION OF TRIFLUOROCHLOROETHYLENE IN 2-PROPANOL SOLUTION. Chutny, B. (Inst. of Nuclear Research, Rez, Czech.); Liska, F.; Dedek, V. pp 31-50 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The γ-initiated addition of 2-propanol to trifluorochloroethylene gives a number of tertiary alcohols (telomers): of these 2-methyl-3,3,4-trifluoro-4-chloro-2-butanol; 2-methyl-3,3,4,5,5,6-hexafluoro-4,6-dichloro-2-hexanol; 2-methyl-3,3,4,5,5,6,7,7,8-nonafluoro-2-octanol were of special interest and were isolated. These telomers, together with small amounts of higher telomers and polymeric TFCE, were isolated by distillation and gas chromatography. Using higher doses of ionizing radiation, at which the TFCE was completely exhausted from the solution, partially dechlorinated telomers could be isolated. The concentration of all radiochemical products, including acetone, and chloride and fluoride ions, were followed as functions of concentration of TFCE in the solution, of dose, of dose rate and of temperature. The mechanism of the telomerization, as well as that of the dechlorination reactions is discussed, and kinetic constants of the telomerization reaction were evaluated. (auth)

**13915** SHORT-LIVED SPECIES: IDENTIFICATION AND KINETIC MEASUREMENTS. Cercek, B.; Land, E. J.; Swallow, A. J. (Christie Hospital and Holt Radium Inst., Manchester, Eng.). pp 51-68 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Electron accelerators were used as sources of radiation for pulse radiolysis, a technique by which numerous short-lived species were identified and studied. The hydrated electron is now well characterized and measurements for the activation energies of its reactions have given values in the range 1.6 to 4.5 kcal-mole$^{-1}$. Halogen atoms were shown to form complexes with organic compounds and complexes between halogen atoms and ions were identified in aqueous solution. A ferric hydroperoxide complex and a ferric hydride are described. Excited states of aromatic compounds were observed in solution, ion recombination is an important mechanism for their formation. Measurements of the extinction coefficients of triplet-triplet absorptions were made. Hydroxy-aromatic free radicals were prepared and their spectroscopic and kinetic properties studied. Different isomeric radicals can sometimes be distinguished. Reduced aromatic radicals in various isomeric forms were also studied at various pH values. (auth)

**13916** RADIATION-INDUCED ADDITION OF 2-PROPANOL TO MALEIC ACID. Kucera, J. (Inst. of Nuclear Research, Rez, Czech.). pp 69-76 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

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Irradiation of a solution of maleic acid in 2-propanol with $^{60}Co$ gamma rays (doses 1 to $10 \times 10^{20}$ eV/ml) produced terebic acid (3-carboxy-4-hydroxy-4-methylvaleric acid lactone) with a chemical yield up to 76% and a G-value of 17.4. As a byproduct diaterebic acid, the nonlactonic form of terebic acid, was found by means of paper chromatography with a G-value of up to 5.1. Using the same method low yields of a number of further acids were identified: fumaric, succinic, methylsuccinic, ethylsuccinic, isopropylsuccinic, and 1,2,3,4-cyclobutanetetracarboxylic acids. These compounds originated partly from the addition of products of 2-propanol radiolysis, i.e. the alkyl radicals, to the maleic acid and partly by isomerization and dimerization of this acid. Thus in this case maleic acid also behaves as a radical scavenger. The influence of maleic acid concentration, radiation doses, dose rate, and temperature was also studied. The addition of benzophenone or ammonia decreases only partly the production of terebic acid, whereas the addition of tetrabromomethane or hydrogen bromide slightly increases the yield of this acid and suppresses the diaterebic acid completely. From these results it was possible to conclude that, unlike similar nonchain photoaddition, radiation addition is a chain reaction with 3 to 6 chain transfers. The reaction probably proceeds by means of two different mechanisms, of which the first is a radical-chain mechanism and the second, which predominates, an ionic-chain mechanism. The influence of temperature is very complex. (auth)

**13917** CONTRIBUTION TO THE SULPHOXIDATION OF HIGHER MOLECULAR n-PARAFFINS. Asinger, F.; Saus, A. (Technische Hochschule, Aachen). pp 77-89 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The sulfoxidation reaction, which is of interest for the manufacture of biologically soft detergents, gives higher amounts of disulfonic acids than are expected theoretically. This is due to an inhomogeneity in the reaction mixture caused by the water that is formed in side reactions. The ratio of mono- to disulfonic acids depends on the conversion of paraffins. Technically utilizable compounds are obtained by conversions lying below 5%. It seems impossible to find a suitable solvent with which to homogenize the reaction mixture so that the theoretically expected ratios are obtained. The low reaction velocity can be increased considerably by adding small amounts of special compounds, such as chloromethanes or acetic anhydride to the reaction mixture, the latter giving optimum results at about 50 to 60°C. As reaction initiators, gamma rays give the best results, followed in order of decreasing effectiveness by uv light, and ozone. (auth)

**13918** A PILOT PLANT FOR THE PRODUCTION OF SULPHONIC ACIDS BY GAMMA IRRADIATION IN PRESENCE OF WATER. Roesinger, S. (Farbwerke Hoechst AG, Frankfurt am Main). pp 91-107 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The reaction of industrial long-chain paraffins with sulfur dioxide and oxygen initiated by gamma irradiation to produce the corresponding sulfonic acids was tested in a continuously operating pilot plant. The aqueous reaction mixture is irradiated in a 50-liter reactor by a 10,000-Ci cobalt source and transferred to a separator in which the sulfonic acid is obtained as an aqueous extract by phase separation. The nonreacted hydrocarbon, with which feedstock paraffin is admixed, is recirculated to the reactor and reacted with the recycled gaseous mixture. Yields of up to 1 kg/h of sulphonic acids were obtained. The influence of dose and dose-rate of the gamma irradiation and of the residence time in the radiation field on product and yield was investigated. Apart from the temperature dependency of sulfoxidation, results will also be presented on the effect of gas composition and cycle speed of the gas on the reaction rate. The water-clear extracts obtained in the separator contain 10 to 30% sulfonic acid and equimolar amounts of sulfuric acid, depending on water addition. All extracts can be processed by well-known methods to give the corresponding sulfonates. Estimates for a large-scale plant are discussed on the basis of the results. (auth)

**13919** THE USE OF ELECTRON ACCELERATORS FOR CARRYING OUT RADIATION CHEMICAL PROCESSES IN THE GASEOUS PHASE. Kon'kov, N. G.; Antonov, V. N.; Gorgonov, V. I.; Dzhagatspanyan, R. V.; Lyaskin, Yu. G.; Osipov, V. B.; Panin, Yu. A. (All-Union Research Inst. of Radiation Techniques, Moscow). pp 109-13 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In Russian).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The problem of using electron accelerators for initiating radiation chemical processes in the gaseous phase is considered. Magnetic fields of different configurations are suggested with the aim of improving the electron utilization coefficient. A study was made

of a process using radiation to purge industrial chlorine of the hydrogen that is formed during the electrolysis of sodium chloride solution, and that gives rise to explosive mixtures under pressure. A laboratory facility was developed for studying the process of separating hydrogen from industrial chlorine. A description is given of the work on the chemical dosimetry of gaseous reaction products using chromatographic methods. The possibilities of using electron accelerators in the chemical industry are discussed. (auth)

**13920** SOME ASPECTS OF RADIATION-INITIATED COPOLYMERIZATION. Hummel, D. O. (Univ., Cologne). pp 117-33 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Radiation-initiated copolymerization is an important link between radiation chemistry and polymer chemistry. Theoretical and practical aspects are discussed for the following processes and systems: statistical, alternating, and block copolymerization as well as copolymerization in the solid state. (auth)

**13921** CHEMICAL ENGINEERING STUDIES IN RADIATION POLYMERIZATION OF VINYL MONOMERS: EMULSION POLYMERIZATION. Stahel, E. P.; Stannett, V. T. (North Carolina State Univ., Raleigh). pp 135-50 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The theories behind successful development of radioinduced emulsion polymerization are presented in context of the latest work in this field. A recirculating flow reactor system was used to study the radioinduced emulsion polymerization of styrene and vinyl chloride. The emulsion is recirculated through an all stainless steel six-liter system from a stirred vessel through relatively long transfer lines to a helical flow reactor positioned within a high-intensity $^{60}Co$ irradiation unit. The pilot plant is equipped with automatic temperature measurement and control for operating above and below room temperature. Constructed of standard stainless steel tubings and fittings, the system is modular in design to facilitate changes in configuration. Mathematical analysis of the engineering flow system is carried out utilizing the model styrene system for which Smith–Ewart kinetic behavior is assumed. Polymerization rate expressions so formulated are incorporated into a mathematical model for the conversion history in the system using engineering models for each of the flow elements. Major departure from standard batch kinetic behavior was found in the flow reactor scheme employed. The mixing of fluid elements of different reaction time histories gives rise to a major second effect believed to be the rapid transfer of emulsifier. Operating conditions of the flow system minimizing this effect are shown to yield results consistent with the theory of Smith–Ewart, including the 0.6 power rate dependence on soap concentration. Operation under conditions where conversion per pass in the flow reactor is high and the total volume of the system is large compared to the reactor volume, show a soap dependence markedly higher. Effects of the system engineering variables of temperature, agitation, emulsion composition, system volume ratios, and flow rate are presented. Rates as high as 15% per minute are reported for a standard styrene emulsion. The pilot plant demonstrates the engineering feasibility of flow reaction systems utilizing radiation initiation to carry out emulsion polymerization. (auth)

**13922** INFLUENCE OF REACTION CONDITIONS ON THE FORMATION OF RADIATION-INDUCED CROSS-LINKS IN POLYSTYRENE. Heusinger, H.; Rosenberg, A. (Technische Hochschule, Munich). pp 151-64 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Radioinduced crosslinking in polystyrene was investigated using the method of gel determination given by Charlesby. Irradiation was performed in high vacuum. The major part of the crosslinks in polystyrene is produced during irradiation in a "hot reaction," which is not influenced by temperature in the range of 30 to 70°C. From ESR measurements at −196°C it can be deduced that recombination of short-lived radical pairs is responsible for this reaction. Additional crosslinks are formed in a post effect (~10%). A kinetic analysis of the increase of crosslink formation with storage time at 30°C shows this reaction to be of first order. For long storage times (10 days at 30°C), especially at higher temperatures (40 to 80°C), the initial increase of crosslinking is followed by a decrease. This can only be explained if these crosslinks are formed during radical decay. Therefore there must be two post-effect reactions in the solid polymer with different activation energies. It appears probable that the post effect is due to trapped cyclohexadienyl and benzyl radicals, which are the primary radical species in polystyrene. The first order kinetics found for the increase in crosslinking during storage are ascribed to a transformation of cyclohexadienyl to benzyl radicals. By dissolution of the polymer with increasing storage time, the reaction of cyclohexadienyl radicals with benzyl radicals, which leads predominantly to disproportionation, is replaced by recombination of 2 benzyl radicals to form crosslinks. At higher temperatures and long storage times, the benzyl radicals in the solid polymer must also disappear by reactions that do not form crosslinks, probably by producing double bonds. Using additives such as anthracene, naphthoquinone, distyrylbenzene, and hexachlorocyclohexane, crosslink formation in the post effect is suppressed at low doses. With anthracene and distyrylbenzene as additives, at higher doses some sensitization of crosslinking is observed. (auth)

**13923** RADIATION-INDUCED CROSSLINKING OF NATURAL AND SYNTHETIC ELASTOMERS IN EMULSION OR DISPERSION. Laizier, J. (CEN, Saclay, France); Noel, M. T.; Veber, A.; Pordes, M. pp 165-78 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The industrial use of emulsions or dispersions of natural or synthetic elastomers depends on whether they satisfy a certain number of basic criteria. Factors essential for the industrial production of latex and production of dry elastomers from radiation-crosslinked latex are considered. These elastomers should have the same basic properties as those obtained in latex vulcanized chemically by the conventional method and their production cost should be competitive. Two methods of irradiation were studied, by $^{60}Co$ gamma rays and by electrons, using a particle accelerator. The effect of various additives in reducing the irradiation doses needed for a correct crosslinking was studied. Halogen compounds were found to be particularly effective and two of them, chloroform and carbon tetrachloride, made it possible to obtain elastomers with all the desirable characteristics at low irradiation doses. Identical results can be obtained with the addition of polymerizable monomers (vinylic, acrylic etc.). Under actual industrial conditions, a strength of 300 kg/cm$^2$ was obtained for films of natural latex irradiated to 1 Mrad with electrons and containing small amounts of $CCl_4$. The braking elongation (%) was around 1000%. Under the same actual conditions, polychlorprene films irradiated to 0.5 Mrad showed a tensile strength of 210 kg/cm$^2$. These figures corresponded to those obtained by conventional chemical methods. The elasticity obtained was in keeping with the definition according to which a body is said to be elastic if it shows a residual elongation lower than or equal to 5%, after 5 min of percentage elongation equal to half the percentage breaking elongation. The irradiation doses needed at present to obtain such elasticity are uneconomically high. By adding small amounts of elemental sulfur (0.2%) or certain organic thio-derivatives, mixed with adequate amounts of chlorinated additives, it was possible to obtain a residual elongation lower than 5%. It is essential to obtain a sufficient mechanical stability that is constant in time. The same requirement applies to chemical stability and viscosity. As a result of studies on suitable stabilizing agents and methods of mixing additives with latex, it was possible to prepare radiation-cross-linked emulsions satisfying these various requirements. The results relating to ageing show that the presence of anti-oxygen agents is essential. Of the numerous substances tried, 2,2'-methylenebis (4-methyl-6-tert-butylphenol) was found to be most effective. A natural latex containing 0.75% of this substance, as well as the additives described earlier, after irradiation to 1 Mrad, gives dry elastomer films, whose ageing is comparable to that obtained in conventional vulcanization. (auth)

**13924** RADIATION CROSS-LINKING OF ELASTOMERS AND ADHESIVE CEMENTS FOR THERMOSENSITIVE MATERIALS. Chadeyron, P.; Bex, G.; Balestic, F. (Centre d'Etudes Scientifiques et Techniques d'Aquitaine, Le Barp, France). pp 179-203 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

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The vulcanization by $^{60}Co$ gamma rays of halocarbon elastomers used as binders for thermosensitive materials was studied with a view to determining optimum irradiation conditions. Various fac-

tors were studied systematically including the chemical structure of the polymer, its preparation for irradiation, the presence of polyfunctional vinylic additives, dose, and dose rate. Mechanical tests showed that the optimum crosslinking took place at a dose of 4 Mrad in the case of crude rubber and 1 Mrad in the presence of certain polyallyl esters, and this has a definite industrial interest. The polyepoxy cements used for joining thermosensitive materials have disadvantages with regard to the conditions of use, mechanical characteristics, and chemical compatibility. A modified cement was developed by the stoichiometric reaction of polyfunctional vinylic monomers (acrylic acid, allylamine, acrylamide, etc.), with the terminal epoxy groups; to resin thus modified can be added a crosslinking monomer, which may or may not be identical with the modifying agent (acrylonitrile, styrene, divinyl benzene, etc.). Gamma irradiation at a dose of 300,000 rads and a dose rate of 750,000 rad/h produces optimum hardening and irradiation up to 1 Mrad perfects the mechanical characteristics. (auth)

**13925** HYDROPHILIC SILICONE RESINS OBTAINED BY RADIATION GRAFTING. Laizier, J. (CEN, Saclay, France); Wajs, G. pp 205-14 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

N-vinylpyrrolidone was grafted radiochemically on a silicone resin by pre-irradiation in the presence of oxygen. Under these conditions, peroxide groups capable of initiating radical copolymerization are formed. The trapped radicals do not seem to make any contribution. An RTV(Room Temperature Vulcanization)-type silicone resin was used, i.e., a poly(dimethylsiloxane). The unsaturated product was transparent. Silicones containing phenyl groups as well as saturated resins were also studied. Irradiation with $^{60}$Co gamma rays was performed in the 10-kCi irradiator. Brief pre-irradiation tests with an electron accelerator were also performed. The amount of polyvinylpyrrolidone(PVP) grafted depended on the pre-irradiation dose and dose-rate as well as on the temperature and duration of the grafting proper. These different parameters were analyzed. The grafting efficiency of PVP can be as much as 60%. The grafted copolymers are more or less opaque and colored sections show that grafting remains peripheral. The transparency can be restored by immersion in water. The swelling in water is such that the ratio of absorbed water to grafted PVP varies between 0.8 and 1.5. When the grafting efficiency is higher than 50%, the grafted PVP redissolves after swelling. The redissolving is due to the breaking of the grafted chains. For grafting rates below 30%, the grafted PVP silicones have notably high thermal stability. Examination of some properties of the grafted PVP silicones shows the additive nature of the properties of the grafted copolymers. (auth)

**13926** SOLID-STATE POLYMERIZATION: RADIATION-INDUCED SOLID-STATE POLYMERIZATION OF TRIOXANE. Hayashi, K. (Hokkaido Univ., Sapporo); Ito, A.; Okamura, S. pp 215-32 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Studies on radioinduced solid-state polymerization of trioxane are reviewed. It was found that a chemically controlled propagation reaction took place under the strong influence of the structure of the monomer crystal, and a three dimensionally oriented polymer crystal having a twin structure was formed. The kinetics of this polymerization were compared with those of tetroxane and pentoxane. ESR and mass spectrometry were used to clarify the primary process of the polymerization reaction. A pilot-scale study is introduced. (auth)

**13927** RADIATION-INDUCED SOLID-STATE POLYMERIZATION. Tabata, Y.; Miyairi, T.; Katsura, S.; Ito, Y.; Oshima, K. (Tokyo Univ.). pp 233-45 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Radioinduced solid-state polymerization of dimethyl itaconate and diethyl itaconate was carried out under various conditions. The effect of pressure on the solid-state polymerization of diethyl itaconate was examined; it was found that an induction period first appears under high pressure. The effect of pressure on the polymerization was found to be greater when diethyl itaconate was in a glassy state rather than in a crystalline state. In this solid-state polymerization, a nucleation process of polymer production in the initial stage of polymerization is very important, but the process is very difficult to detect using standard methods. A new method for detecting the nucleation process is presented. "Positron annihilation" measurements in solid monomers during polymerization are shown to provide very useful information for analyzing the initial stage of polymerization. The deformation of the crystal lattice and the production of defects can be detected by the measurement of the lifetime of a positronium and the probability of the formation of a corresponding positronium. For positronium interacts with active species produced in the solid monomer system, allowing the active species itself to be "detected" by this method. (auth)

**13928** SCOPE OF RADIATION-INDUCED IONIC PROCESSES IN LIQUIDS AND SOLIDS: FUNDAMENTALS AND APPLICATIONS. Williams, Ff. (Univ. of Tennessee, Knoxville). Contract AT(40-1)-2968. pp 247-68 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

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The role of ions and electrons in the radiation chemistry of condensed systems is considered. The structure of excess electrons is discussed and recent ESR results on the nitrogen hyperfine coupling of the trapped electron in acetonitrile-$d_3$ are presented. A kinetic analysis of ion recombination in liquids suggests that charged species recombine by either geminate or homogeneous processes. Geminate recombination in mobile liquids is a fast process complete in less than $10^{-7}$ sec whereas the corresponding lifetime of free ions undergoing homogeneous recombinations is $\sim 10^{-2}$ sec at a dose rate of 1 Mrad/h. As molecular diffusion becomes slower, the time scale for recombination is extended, and relatively high concentrations ($\sim 10^{-3}$ M) of ions and electrons can be trapped in viscous glasses and certain polar molecular crystals. By the use of positive-ion and electron scavengers, it is possible to compete with geminate recombination in liquids. The role of free ions is illustrated by studies on the polymerization of anhydrous monomers. These systems give G-values ranging up to $10^3$ and offer potentialities for commercial operations. Lastly, it has been shown that the photobleaching reaction undergone by trapped electrons in gamma-irradiated crystalline organic cyanides can be reversed thermally such that the trapped electron is regenerated with the original intensity. (auth)

**13929** CHEMICAL ENGINEERING STUDIES IN RADIATION POLYMERIZATION OF VINYL MONOMERS: IONIC HOMOGENEOUS POLYMERIZATION. Stahel, E. P.; Stannett, V. T. (North Carolina State Univ., Raleigh). pp 269-87 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The theories behind the seccessful development of radioinduced ionic polymerization in the liquid phase are reviewed in context of the latest work in this field. A recirculating flow reactor system was used to study the radioinduced polymerization of styrene and $\alpha$-methylstyrene in bulk and solution. Reactant monomer or monomer solution is recirculated through an all stainless steel six liter system from a stirred vessel through relatively long transfer lines to a tubular flow reactor positioned within a high-intensity $^{60}$Co irradiator. The pilot plant is equipped with an automatic temperature measurement and control system for operating above and below room temperature. Constructed of standard stainless steel tubings and fittings, the system is modular in design to facilitate changes in configuration. A polymerization rate expression formulated from the literature is incorporated into a mathematical model for the conversion history in the system using engineering models for each of the flow elements. The performance of the system is simulated on an analog computer. Limiting cases are solved analytically and more general cases of nonideal flow, numerically on a large digital machine. The flow reactor is part of a small-scale pilot plant where both final purification and polymerization are accomplished. Continuous automatic monitoring of the ultra-dry moisture level and degree of conversion are carried out by in-situ conductivity measurements and changes in refractive index. Final purification and drying to the sub one part per million range are accomplished on a low temperature molecular sieve bed. Studies of the dynamics of the drying process indicate the rate controlling step is intra-particle mass transfer. Interpretation of the rates of polymerization of styrene as a sum of a free radical contribution and an ionic contribution are indicated, while polymerization of $\alpha$-methylstyrene proceeds by a cationic route only. Nonideal behavior of viscous flow through the element of the engineering system was studied by stimulus response techniques and the real conversion

time behavior of the engineering flow system characterized under various conditions. (auth)

**13930** THE INFLUENCE OF CABLE DIMENSIONS ON THE DEGREE AND HOMOGENEITY OF CROSS-LINKING OF POLYETHYLENE INSULATION. Wiesner, L.; Gurke, G. pp 289-99 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

For routine irradiation with 3-MeV electrons of polyethylene insulated cables with copper-core diameters of more than 1 mm, the problem arises as to what conditions will give a homogenous dose distribution and, therefore, a proper crosslinking throughout the whole insulation in both radial and axial directions. Theoretically 3-MeV electrons will be absorbed almost completely by a layer of 1 mm copper, a fact that would account for improper crosslinking in the "shadow zones" behind thicker copper cores leads for one-sided irradiation. Comprehensive investigations of the degree of crosslinking by the determination of gel fractions, however, revealed that even for larger sizes, one-sided irradiation will have considerable effect in the shadow zones, if a backscattering device is used. The results of the investigation lead, for a large range of cable dimensions, to a considerable enhancement of the efficiency of use of the beam energy and an equally important reduction of the normally applied overdose that was necessary to guarantee a certain minimum degree of crosslinking in all parts of the polyethylene insulation. Both effects of the utilization of backscattered electrons result in a substantial saving of irradiation costs. (auth)

**13931** RADIATION MODIFICATION OF TEXTILES. Hoffman, A. S. (Massachusetts Inst. of Tech., Cambridge). pp 301-18 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The principles of radiation modification of textiles are reviewed. The important molecular factors controlling such processes and their interaction are considered. These factors include the G-values for radical formation, local propagation, transfer and termination rate constants, local monomer concentration and its coefficient of diffusion within the polymer matrix, radiation dose rate, temperature, and the presence of nonreactive (e.g. solvent) species. Economic factors are also considered. Following this there is a review of the most pertinent recent published work in this field, including the patent literature. This survey is broken into two parts: bulk effects and surface effects. Emphasis is placed on durable press and strain release properties. The chemistry of durable press and its application within the field of radiation chemistry are covered. The principles of surface chemistry are discussed, as they relate to important wetting phenomena in textile fibres and fabrics. Data are presented from a series of studies on the radiation modification of surface wettability of textile materials. (auth)

**13932** KINETICS OF RADIATION GRAFTING OF POLYESTER-ACRYLIC ACID SYSTEMS AND SOME TEXTILE PROPERTIES OF THE FIBRES OBTAINED. Blin, Marie-Francoise; Candau, R.; Gaussens, G.; Lemaire, F. (CEN, Saclay, France). pp 319-30 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Study of the kinetics of direct radiochemical grafting of ethylene polyterephthalate by acrylic acid made it possible to determine the effects of such parameters as dose, dose rate, temperature, and swelling of the homopolymer. The kinetics obtained, in a manner that would be highly reproducible in autoclaves and a circulation system, do not vary either with the physical nature of the samples used or with the circulation conditions within the limits investigated. The conversion curves obtained are of a strongly self-accelerating nature, which then tends to slow down, and grafting becomes appreciable only when the doses are higher than 50,000 rad. An increase in temperature and the presence of appropriate solvents, in particular water, promote the reaction. Microscopic examination of sections of grafted and dyed fibers showed that grafting was regular through the whole cross-section of the fiber. The fibers modified by grafting with acrylic acid under the conditions used for this work are practically free of any homopolymer. They have a varied and high dye affinity. (auth)

**13933** ELECTRON SPIN RESONANCE STUDIES OF RADIATION GRAFT-COPOLYMERIZATION: POLYETHYLENE-METHYL METHACRYLATE SYSTEM. Seguchi, T.; Tamura, N. (Japan Atomic Energy Research Inst., Takasaki). pp 353-62 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The behavior of trapped radicals in various kinds of polyethylene was investigated after irradiation and during grafting by electron spin resonance. Polyethylene in powder form was irradiated with electrons from an accelerator, after which it was brought into contact with MMA vapor. With high-density polyethylene irradiated up to 3 Mrads at room temperature and in vacuum, two kinds of radicals were detected, the alkyl and allyl-type radicals. The alkyl radicals decay faster than the allyl radicals. When MMA is introduced into the sample, the allyl radicals decay rapidly and the propagating radicals of MMA grow and then gradually decay; grafting is observed. When irradiation is carried out in air, the radicals detected consist almost entirely of alkyl radicals. After prolonged storage in vacuum, however, some of the alkyl radicals convert into the allyl radicals and others show second-order decay. This phenomena suggest that the alkyl radicals migrate to the double bond and, at the same time, the recombinative decay of part of radicals. The allyl radicals thus obtained can also initiate the grafting reaction. When MMA is introduced into polyethylene immediately after irradiation in air and evacuation, the decaying behavior of alkyl radicals is similar to that observed in vacuum. However, there is no growth of allyl radicals; the growth of propagating MMA radicals is observed instead. These results suggest that the radicals that can initiate the grafting in irradiated polyethylene are allyl-type and that the alkyl radicals do not directly react with monomer. All the radicals trapped at room temperature are expected to reside in the crystalline or rigid-molecular regions. (auth)

**13934** EFFECT OF GAMMA RAYS IN THE TANNING OF HIDES. Pastuska, G. (Bundesanstalt fuer Materialpruefung, Berlin). pp 363-8 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Organic ions can be oxidized by $\gamma$ rays in the presence of water and oxygen. It is also possible for reduction to take place. Such reductions produce a high yield in the presence of organic material. Solutions of chromium(VI) salts are reduced in such media to chromium(III) salts, which are well known as tanning materials. Solutions of chromium(III) salts are obtained in an enclosed system of hide, water, and chromate or bichromate salts by radioinduced reduction. The chromium(III) salts are absorbed by the hide. The experiments described were conducted on calf hides. The pickled pelt was impregnated with a solution of potassium bichromate, sealed in a polyethylene bag and exposed to $\gamma$ rays. After treatment it was tested to determine whether the material had the characteristics of leather. It was found that a $\gamma$ dosage of 5 Mrad is required to turn hide into leather. The shrinkage temperature of the leather was about 80°C. Physical tests on the leather showed that the $\gamma$ dosage should not be more than 10 Mrad. It is possible to combine the new treatment with retanning. (auth)

**13935** GAMMA-RAY INDUCED POLYMERIZATION OF UNSATURATED POLYESTER IN RED MUD. Yuan, H. C.; Hsu, W. W.; Wang, U. P.; Wu, C. C.; Shieh, J. S.; Chang, M. L.; Kung, T. D. (Union Industrial Research Inst., Hsinchu, Taiwan). pp 383-97 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

A series of investigations was conducted on the $^{60}$Co-irradiation of a mixture of unsaturated polyester and styrene in the presence of red mud. A total dose of approximately 0.8 Mrad was sufficient to cure the mixture to a strong composite. The relation between the process variables and the impact strengths of the composites was studied by means of response surface technology. (auth)

**13936** STUDY OF THE POLYMER-SUBSTRATE BONDING OBTAINED BY RADIATION IN RESIN-TREATED WOODS. Guillemain, Jeanine (Centre Technique du Bois, Paris); Laizier, J.; Marchand, J.; Roland, J. C. pp 417-33 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The use of homogeneous ternary mixtures of a monomer, a sol-

vent, and water gives excellent dimensional stability to treated beech wood. This is not the case when a pure monomer is used or even with a monomer in aqueous emulsion or in mixture with a solvent such as dioxane. In the latter cases, very low or no stabilization was obtained. In the case of ternary mixtures, the polymer retained by the wood could not be totally extracted. The fixation of the polymer increased with dose up to a plateau, whose height varied with the type of solvent. Electron-microscopic examination of woods thus treated showed a profound change in the cell wall. The cellulose layers seemed to undergo filling and be in a swollen state, which may be attributed to grafting. Various methods of degradation of resin-treated woods were used in order to separate and characterize the copolymer–hydrolysis of the polyoxides to isolate lignin, removal of lignin with sodium chlorite to obtain holocellulose, determination of pentoxanes and determination of methoxyl groups. At every stage the isolated polymer was analyzed by infrared spectroscopy. Grafting was found to have occurred on the cellulose fraction of the material. A supplementary crosslinking reaction may be assumed from the increase in mean molecular mass and the decrease in solubility of the cellulose. Comparison of the respective weights, which differ according to the order in which the extractions are performed, shows that lignin has a retentive effect on the polymer; this retention may be interpreted as grafting. The "resin-treated woods," thus characterized, appear to be quite different compounds from the "irradiated impregnated woods." Their dimensional stability is due to chemical fixation of the polymer on the ligno-cellulose material. There is no doubt that this fixation occurs on cellulose, in which it is accompanied by crosslinking; it is also not improbable that it occurs on lignin. This chemical change is accompanied by a marked change in the structure of the cell wall. (auth)

**13937** IMPREGNATING SYSTEMS FOR PRODUCING WOOD–PLASTIC COMPOSITE MATERIALS AND RESINIFIED WOODS BY RADIOCHEMICAL MEANS. Laizier, J.; Laroche, R.; Marchand, J. (CEN, Saclay, France). pp 435-50 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB–236; CONF-690805.

The effect of the nature of the components in the impregnation mixture on the characteristics of wood–plastic combination was studied in the case of beech by applying a wide variety of compositions. In particular, the effect of water (in the impregnator, and in the form of moisture in the wood) on the characteristics of the products obtained was determined. It was shown that, in place of the conventional method for preparing resinified woods (using a ternary monomer-solvent-water mixture), it is possible to use a method involving comonomers, which obviate the need to dry the wood after treatment. The evaluation of the results obtained is based on the value of the impregnation rate and on the modifications in microscopic structure; these emphasize the differences between the types of filler and enable comparisons to be drawn with the dimensional stabilities observed. Measurements of variations in dimensions and the recurrence of moisture made it possible to establish a classification based on the types of monomer used and the operating conditions. It is shown that a whole range of products is obtained, the properties of which differ widely and are comparatively easily adaptable to the purpose specified. These properties illustrate clearly the differences and characteristics of resinified woods as opposed to conventional wood–plastic materials. (auth)

**13938** STUDIES ON THE PREPARATION OF FIBRE–POLYMER COMPOSITES FROM STYRENE SYSTEMS BY RADIATION POLYMERIZATION. Jayaraman, T. M.; Thacker, Ramaden C. (Bhabha Atomic Research Centre, Trombay, India). pp 453-65 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB–236; CONF-690805.

The preparation and properties of fiber–polymer composites from Indian woods, bagasse, plywood and particle boards, and jute and coir are described. The conditions required for the polymerization of styrene-unsaturated polyester mixtures at low polyester to styrene ratios and the effect of additives and post irradiation heating on this system were investigated, and the feasibility of such techniques in practical applications is discussed. The effects of polymer loading on jute and coir with styrene-polyester from aqueous emulsions, and with styrene-butadiene from a solution of the copolymer in carbon tetrachloride solution are also reported. (auth)

**13939** WOOD–PLASTIC WORK IN AUSTRIA. Proksch, E. (Oesterreichische Studiengesellschaft fuer Atomenergie GmbH, Seibersdorf, Austria). pp 467-73 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB–236; CONF-690805.

Selected experimental work done in Austria in the field of radiation-cured wood–plastic combinations is presented. Such combinations were made mainly from Austrian spruce, beech, and ash by impregnation with monomers such as methyl methacrylate and styrene–acrylonitrile. For spruce, a high summerwood percentage is necessary for sufficiently good impregnation. Beech can be impregnated without difficulty. Ash is somewhat resistant to impregnation. Use of methyl methacrylate without any additives yielded products with the best mechanical properties. The flammability of such combinations is high but can be suppressed by combined addition of tetachloromethane and a flame retardant. Dimensional stability and weather resistance are far better for styrene–acrylonitrile combinations than for products made from methyl methacrylate. Work presently in progress is mainly related to early stages of commercialization. (auth)

**13940** THE RADIATION POLYMERIZATION OF IMPREGNATED FIBROUS MATERIALS: RECENT DEVELOPMENTS IN THE UNITED KINGDOM. Dalton, F. L.; Hills, P. R. (Atomic Energy Research Establishment, Wantage, Eng.). pp 475-86 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB–236; CONF-690805.

The UKAEA's timber impregnation service and the work done to develop one particular composite to a production level are described. This approach was subsequently followed for a number of other timber species, and practical composites produced. A number of uses are described and the present situation regarding the commercialization of composites on a large scale, using solid timber, veneers, and synthetic boards is mentioned. (auth)

**13941** RADIATION TREATMENT OF ELASTOMERS. Balestic, F. (Centre d'Etudes Scientifiques et Techniques d'Aquitaine, Le Barp, France). pp 491-7 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB–236; CONF-690805.

The treatment of elastomers by irradiation was closely linked with the development of radiation chemistry, of which the paper traces the main stages: the pioneering period, fundamental research, studies connected with reactor technology, and investigations into radiochemical reactions for industrial purposes. An examination was made of the various processes for radiochemical vulcanization of natural and synthetic rubbers. This examination shows that expensive elastomers, some latex products, and binders for rocket propellants have the best industrial potential. (auth)

**13942** COLD-RADIOHARDENING COMPOSITIONS FOR COATING OR OTHER APPLICATIONS. Blin, Marie-Francoise; Gaussens, G. (CEN, Saclay, France). pp 499-511 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB–236; CONF-690805.

The crosslinking or crosslinking grafting of mixtures of monomers and polymers by fast electrons was studied, using solutions whose compositions varied considerably with respect to the nature of the monomers and polymers as well as the monomer–polymer ratio. Three types of polymer were studied: linear polyesters obtained by the polycondensation of maleic and phthalic acids or anhydrides and propylene glycol; epoxy polymers modified by unsaturated polyester resins or by monounsaturated monocarboxylic acids; polyacrylics, acrylic-type resin with olefinic unsaturates. It was thus possible to determine the influence of different parameters, dose between 1 and 2 Mrad, dose rate between 0.008 and 1.7 Mrad/s, reactivity of the monomer–polymer mixture, and atmospheric oxygen, on the rate of gel formation. Such mixtures give a whole range of coatings differing in physical and chemical characteristics, depending on the purpose for which they are required. (auth)

**13943** SURFACE TREATMENT OF FIBRE BOARDS WITH MIXTURES OF UNSATURATED POLYESTERS IN STYRENE. Miettinen, J. K.; Autio, T. (Univ. of Helsinki). pp 513-20 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and

Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Results of a research project for development of construction boards provided with a coating of unsaturated polyesters and styrene are reported. Peroxide curing was compared with electron curing by a linear accelerator. Results of weather tests after 3 to 8 months in natural weather conditions are reported. (auth)

**13944** ELECTRON BEAM CURING OF COIL COATINGS. Morganstern, K. H. (Radiation Dynamics, Inc., Westbury, N. Y.). pp 521-8 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The application of electron accelerators for the rapid curing of coatings on coils of steel and aluminum appears to have many practical and economic advantages. A typical conventional coil coating line is discussed and compared to a line employing a radiation source. Specific engineering information on the types of electron accelerators suitable for this application; the relative economics of radiation vs. heat curing; and a number of other peripheral advantages of radiation are discussed. (auth)

**13945** FIBRE-BOARD COATING ECONOMICS. Rotkirch, E. (EKONO, Helsinki). pp 529-42 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The coating of fiber boards with unsaturated polyesters was studied. Both irradiation curing and curing with peroxides gave promising results. The economics of various treatment systems and materials for fiber-board coating, based on the findings of these studies were evaluated. A process optimization for practical purposes is indicated. (auth)

**13946** POLYMERIZATION OF ACRYLONITRILE IN A UREA COMPLEX UNDER THE INFLUENCE OF IONIZING RADIATION. Kishsh, L.; Polgar, Sh. (Research Inst. of Plastic Industry, Budapest). pp 543-51 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In Russian).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Kinetics of the polymerization of acrylonitrile in channel complexes of urea were studied. On the basis of experimental data it is found that for a molar ratio of 1:1 a complex forms within 48 hours. It is shown that the rate of polymerization in a channel complex is several orders higher than that of polymerization of acrylonitrile in bulk. The kinetics of polymerization in a complex is of a self-accelerating nature. Postpolymerization in a complex is studied at temperatures between −35 and −196°C. The following kinetic picture of postpolymerization is obtained: at the beginning of the process the rate of polymerization increases, and then decreases to zero, i.e., there is a limit on the yield. This limit increases with rising temperature, i.e., the kinetic conversion-time curve rises in successive steps. The influence of methyl alcohol on the kinetics of polymerization was also studied. On the basis of kinetic data it is proposed that in the system under consideration the growth of the kinetic chain is slowed down by two kinds of crystal defect. At the site of a nonannealable defect chain growth stops completely and annealable crystal defects cause the stepwise growth of the chain. Consequently, in the initial stage of polymerization the characteristic viscosity of the polymer increases. With increasing conversion the length of the original channel decreases leading to a decrease in mean molecular weight of the polymer. In the polymerization of this system methanol molecules play the part of annealable defects, i.e., they can slow down the growth of the kinetic chain only temporarily. (auth)

**13947** RADIATION CHEMICAL RESEARCH IN THE CENTRAL RESEARCH INSTITUTE FOR PHYSICS. Kosa Somogyi, Istvan. Energ. Atomtech.; 21: 556-60(1968). (In Hungarian).

In the Central Research Institute for Physics systematic radiation chemical research has been carried out for about ten years. This work, which is directed to clearing up the basic radiation chemical processes, was begun for selection of organic cooling and moderating materials for the nuclear reactors. The various processes of energy transfer and arising and disappearing radicals, ions, and stabilized electrons were investigated by chemical analysis, by measurment of electron spin resonance and electrical conductivity, and the application of flash photolysis and pulse radiolysis. Solutions of some industrial tasks were also attempted. (auth)

**13948** EFFECT OF CHARGED PARTICLE ACCEPTORS ON n-HEPTANE γ-RADIOLYSIS. I. Muratbekov, M. B.; Saraeva, V. V. Vestn. Mosk. Univ., Ser. II, Khim.; No. 6, 68-72(Nov–Dec 1969). (In Russian).

The yield of ion pairs on radiolysis of pure n-heptane was shown to be 2.9 and increased up to 3.8 in the presence of acceptors. It was suggested that certain parts of the secondary excited molecules formed on radiolysis of pure n-heptane did not result in formation of new products. (auth)

**13949** EFFECT OF CHARGED PARTICLE ACCEPTORS ON n-HEPTANE γ-RADIOLYSIS. II. Muratbekov, M. B.; Saraeva, V. V. Vestn. Mosk. Univ., Ser. II. Khim.; No. 6, 73-8(Nov–Dec 1969). (In Russian).

Secondary and primary excited molecules were found to be a source of hydrogen atoms and molecules under heptane radiolysis without additions. It was concluded that $N_2O$ molecules react with the primary excited molecules. The rate of electron capture by nitrous oxide was shown to be 5 times that of proton capture by ammonia. (auth)

**13950** PULSE RADIOLYSIS OF NITRIC OXIDE IN AQUEOUS SOLUTION. Seddon, W. A.; Young, M. J. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem., 48: 393-4 1(15 Jan 1970). (AECL-3491).

Pulse radiolysis of aqueous solutions of nitric oxide at neutral pH shows that the reaction initiated by the hydrated electron, $e^-(aq)$, proceeds via $NO^-$ and a new transient thought to be $(N_2O_2)^-$, and not HNO as indicated previously by steady state radiolysis. (auth) (Canada)

**13951** RADIOLYSIS OF AQUEOUS CHLOROFORM SOLUTIONS. Rezansoff, B. J.; McCallum, K. J.; Woods, R. J. (Univ. of Saskatchewan, Saskatoon). Can. J. Chem., 48: 271-6(15 Jan 1970).

Saturated aqueous chloroform solutions (0.07 M) with pH ranging from 0.8 to 12.6 were irradiated with $^{60}Co$ γ radiation in the presence and absence of air. $G(Cl^- + ClO^-)$ increased with increasing pH in the pH range 1 to 3 (aerated solutions) or 3 to 6 (deaerated solutions) and again at pH greater than 10.5. The variation in yield from aerated solutions in the region pH 1 to 3 is attributed to competition between chloroform and hydrogen ions for hydrated electrons. However, such competition cannot account for the pH effect observed in deaerated solutions between pH 3 and 6. Increased yields from both aerated and deaerated solutions at high pH are attributed to the formation of $O^-$ by reaction of hydroxyl radicals and hydroxide ions. Formic acid and oxalic acid were identified as minor products when aerated chloroform solutions are irradiated. (auth) (Canada)

**13952** NEW POLYMERS THROUGH RADIATION OR INTRODUCTION OF THERMAL STABILITY AND OTHER CHARACTERISTICS TO NYLON MOULDING POWDER BY RADIATION INDUCED REACTIONS. DasGupta, S. (Atomic Energy of Canada Ltd., Ottawa). Can. Res. Develop., 3: 37-40(Jan–Feb 1970).

Techniques for graft copolymers, radioinduced grafting, and synthesis of grafted nylon copolymers are described. Some of the results obtained are outlined. It is foreseen that in the not too distant future much of the synthetic work in polymers will involve radiation at some stage in the process. (F.S.A.)

**13953** ELECTRON SPIN RESONANCE STUDY OF TRAPPED ELECTRONS IN IRRADIATED ORGANIC GLASSES AT 4.2°K. Yoshida, H.; Higashimura, T. (Kyoto Univ., Osaka). Can. J. Chem., 48: 504-6(1 Feb 1970).

Electron spin resonance of electrons trapped in organic glasses, ethanol, 2-methyltetrahydrofuran, and 3-methylhexane, were studied at the four different conditions (combination of irradiation with γ rays and measurement at both 77 and 4.2°K). It was evident that the spectral width, $\Delta H_{ms}$, changes irreversibly when the glasses are warmed up to 77°K after the irradiation at 4.2°K: from 6.7, 5.6, and 4.5 to 14, 4.4, and 4.0 G for ethanol, 2-methyltetrahydrofuran, and 3-methylhexane, respectively. These observations strongly support Smith and Pieroni's suggestion that the molecular orientation is not a necessary condition for electrons to be trapped in the irradiated organic glasses. (auth) (Canada)

**13954** $^{60}Co$ γ-RADIOLYSIS OF OXYGENATED AQUEOUS SOLUTIONS OF CYSTEINE AT pH7. Packer, J. E.; Winchester, R. V. (Univ. of Auckland, N. Z.). Can. J. Chem., 48: 417-21 (1 Feb 1970).

In the radiolysis of oxygenated aqueous solutions of cysteine (RSH) at pH 7, short chain reactions occur yielding cystine (RSSR) and hydrogen peroxide. Two competing reaction paths involving reaction of the thiyl radical ($RS\cdot$) with oxygen or thiol anion ($RS^-$) are postulated to explain the results. (auth) (Canada)

**13955** KINETICS OF THE RADIOCHEMICAL GRAFTING OF 4-VINYLPYRIDINE ONTO MEMBRANES CONTAINING POLY-

(ACRYLIC ACID) CHAINS. Chapiro, Adolphe; Jendrychowska-Bonamour, Anna-Maria (Centre National de la Recherche Scientifique, Bellevue, France). Compt. Rend., Ser. C; 270: 27-30 (5 Jan 1970). (In French).

The radiochemical grafting of 4-vinylpyridine onto PTFE membranes containing poly(acrylic acid) chains is carried out with a rate greater than that of the same monomer onto pure PTFE films. The acceleration observed is due to the orientation of monomer molecules along carboxyl chains. This orientation effect decreases only with the fixation of ten pyridine groups on average into the membranes for each carboxyl group. (France)

**13956** CYCLOTRON PRODUCTION OF CARRIER-FREE $^{67}$Ga. Hupf, H. B.; Beaver, J. E. (Oak Ridge National Lab., Tenn.). Int. J. Appl. Radiat. Isotop.; 21: 75-9(Feb 1970).

Carrier-free $^{67}$Ga was produced in 100-mCi quantities in the ORNL 86-in. Cyclotron under conditions obtainable with commercial cyclotrons. Production yields, problems, and a chemical-separation procedure from natural zinc-targets are presented. (auth) (UK)

**13957** SOL'VATIROVANNYI ELEKTRON V RADIATSIONNOI KHIMII. (Solvated Electron in Radiation Chemistry). Pikaev, A. K. Moscow; Izdatel'stvo Nauka (1969). 458p.

The role of solvated electrons in radiolysis and the properties of solvated electrons formed on irradiation of water, alcohols, ammonia, simple esters, etc., are considered. Capture of electrons by polar media is discussed. Experimental data are generalized and systematized. (tr-auth)

**13958** PULSE RADIOLYSIS STUDIES ON THE OXIDATION OF ORGANIC RADICALS IN AQUEOUS SOLUTION. Adams, G. E.; Willson, R. L. (Mount Vernon Hospital, Middlesex, Eng.). Trans. Faraday Soc.; 65: 2981-7(Nov 1969).

Pulse radiolysis has been used to measure directly the absolute rates of oxidation by ferricyanide ion of various radicals produced by OH attack on organic solutes. These include mono, di- and polyhydroxylic compounds, hydroxy acids, polyethylene oxides of molecular weight 200, 6,000, and 20,000 and the amino acid serine. Radicals produced by hydrogen abstraction from $\alpha$ carbon atoms in alcohols are oxidized at, or near, diffusion-controlled rates, whereas the reactions are much slower for radicals formed by OH-attack elsewhere. The technique has been used to measure the percentage OH-attack at the $\alpha$ position for a series of straight and branched-chain alcohols. Oxygen competes with ferricyanide for radical oxidation. The data for oxygen-containing solutions fit a simple radical-competition scheme which has been used to measure rates of peroxy-radical formation. These approach diffusion-controlled limits. (auth) (UK)

**13959** THE PHOTOCHEMISTRY OF FREE RADICALS. THE ACTION OF LIGHT ON RADICALS IN $\gamma$-IRRADIATED FORMAMIDE AND DIMETHYLFORMAMIDE. Pukhal'skaya, G. V.; Kotov, A. G.; Pshezhetskii, S. Ya. (Inst. of Physical Chemistry, Moscow). Khim. Vys. Energ.; 3: 340-5(Jul-Aug 1969). (In Russian).

The radicals resulting from the $\gamma$ irradiation of formamide (FA) and dimethylformamide (DMFA) in aqueous solutions were studied and the effects of visible and uv light on the reactions of these radicals were also studied. Electron paramagnetic resonance studies showed that the radicals $\dot{C}ONH_2$ and $HCON(\dot{C}H_2)CH_3$ are formed in $\gamma$-irradiated FA and DMFA and under the action of uv light these radicals dissociate forming HCO and $(CH_3)_2\dot{N}$. The optical absorption spectra of the radicals $\dot{C}ONH_2$ and $HCON(\dot{C}H_2)CH_3$ in the region 270 to 500 nm were determined. (tr-auth)

**13960** KINETICS OF RADICAL ACCUMULATION IN SOLID POLYMER SUBSTANCES ON IRRADIATION. Makshantsev, B. I. (Moscow Physical-Technical Inst.). Khim. Vys. Energ.: 3: 349-56(Jul-Aug 1969). (In Russian).

A model is proposed for the formation and annihilation processes of radicals under the action of ionizing radiation in systems with intramolecular migration of energy. On the basis of this model the equation of kinetics of radical accumulation and extinction was obtained in which one of the constants ($\alpha$) turns out to be dependent on the degree of polymerization K. Knowledge of the experimental relation of $\alpha$ to magnitude K in a sufficiently wide region permits the determination of the length of the range of exciton along the molecule up to its extinction. The proposed model may be used to explain the question concerning the role of triplet excitations (excitons) in the processes and to evaluate their life time and the coefficient of intramolecular diffusion. (tr-auth)

**13961** DECAY OF THE PEROXIDE RADICALS IN POLYMERS UNDER THE ACTION OF IONIZING RADIATION. Klinshpont, E. R.; Milinchuk, V. K.; Pshezhetskii, S. Ya. (Inst. of Physical Chemistry, Moscow). Khim. Vys. Energ.; 3: 357-63(Jul-Aug 1969). (In Russian).

The effects of ionizing radiation on peroxide radicals in polypropylene and polytetrafluoroethylene were studied by electron paramagnetic resonance. It was shown that the extinction of peroxide radicals is subdued by the equation of the first order with the constants 0.2 and 0.3 $Mrad^{-1}$ for polypropylene and polytetrafluoroethylene, correspondingly. The radiation yield of peroxide radical extinction by calculation of the energy additive absorption constitutes $5 \times 10^3$. The role of peroxide radicals in the mechanism of radiation destruction of the polymers was examined. (tr-auth)

**13962** THE G VALUES OF NITRITE ION IN CONCENTRATED SOLUTIONS UNDER 14.1-MeV NEUTRONS. Vasil'ev, A. G.; Viktorov, D. V.; Rozman, I. M.; Tkachenko, V. V. Khim. Vys. Energ.; 3: 373-4(Jul-Aug 1969). (In Russian).

The radiation yields of nitrite ions in concentrated solutions of ammonium nitrate $C_1$ = 320 g/l and $C_2$ = 640 g/l irradiated by neutron with energy of 14.1 ± 0.3 MeV were calculated to be $G_1$ = 5.0 ± 0.2 ions/100 eg and $G_2$ = 5.7 ± 0.1 ions/100 eg. The G values for irradiation with $^{60}$Co were $G_1$ = 4.4 ± 0.3 ions/100 eg and $G_2$ = 4.6 ± 0.5 ions/100 eg. (tr-auth)

**13963** ROLE OF OXYGEN IN THE RADIOINDUCED SYNTHESIS OF HYDROGEN CYANIDE. Zhdamirov, G. G.; Rumyantsev, Yu. M.; Borisov, E. A.; Dzantiev, B. G. (Inst. of Chemical Physics, Moscow). Khim. Vys. Energ.; 3: 376-7(Jul-Aug 1969). (In Russian).

Hydrogen cyanide and formaldehyde were identified as the products from the radioinduced reaction of gaseous mixtures of nitrogen and hydrocarbon that contained small oxygen impurities. The yields of hydrogen cyanide and formaldehyde were determined colorimetrically. It was concluded that approximately 1% oxygen in a reaction mixture leads to a sharp decrease in the quantity of hydrogen cyanide in the absorber. The mechanism of the action of the oxygen on the system was studied. (tr-auth)

**13964** INVESTIGATION OF POLYMERIZATION OF VACUUM OIL VAPORS BY 0 TO 20 eV ELECTRONS. Artamonov, O. M.; Zyn, V. I. (Leningrad State Univ.). Khim. Vys. Energ.; 3: 378-9(Jul-Aug 1969). (In Russian).

The polymerization of residual vapors of vacuum oil were studied at a pressure of $10^{-6}$ torr under the action of electrons with energies in the region of 0 to 20 eV. The relation of the rate of increase of the polymer film was obtained from the energy of bombarding electrons and by utilization of Kristi formula the corresponding cross sections of polymerization was calculated. (tr-auth)

**13965** SOME REGULARITIES IN THE RADICAL FORMATION IN IRRADIATED PROPYL GALLATE FROZEN SOLUTIONS. Ginzburg, S. F.; Postnikova, M. S. Khim. Vys. Energ.; 3: 381-2(Jul-Aug 1969). (In Russian).

The effects of temperature (−10 to −180°C) on the yields of propyl gallate radicals from the $\gamma$ radiolysis of propyl gallate in water were studied. In order to clarify the role of the products of the radiolysis of water in the formation processes of the propyl gallate radicals upon heating, experiments were conducted using ultraviolet irradiation which does not produce the water radicals. (tr-auth)

**13966** MOLECULAR-WEIGHT DISTRIBUTION OF POLY-(METHYL METHACRYLATE) TRIPHENYL PHOSPHITE ADDITIONS IN RADIOLYSIS. Krasilova, O. I.; Pavlov, A. V.; Kondrat'eva, L. V.; Serenkov, V. I. Vysokomol. Soedin., Ser. B; 11: 678-81(1969). (In Russian).

High-speed sedimentation was used to obtain curves for molecular weight distribution of $\gamma$-irradiated and nonirradiated poly(methylmethacrylate) (PMMA). PMMA with triphenyl phosphite additions was also studied. It was found that the region of molecular weights for nonirradiated PMMA lies within the limits from $8 \times 10^4$ to $1.6 \times 10^6$. Upon irradiation at 15 Mrad the molecular weight distribution shifts to $6 \times 10^4$ to $1.4 \times 10^5$. The curve for irradiated PMMA with triphenyl phosphite additions lies within the limits $4.7 \times 10^4$ to $3.4 \times 10^5$. (tr-auth)

**13967** ON THE OPTICAL ABSORPTION OF X-RAY IRRADIATED $NaClO_3$ CRYSTALS. Raesaenen, Vilho; Esselstroem, Raili (Univ. of Turku, Finland). Ann. Acad. Sci. Fenn., Ser. A VI, No. 256, 1-8(1968).

The optical absorption of x-irradiated $NaClO_3$ crystals was investigated at room temperature in the wavelength region from 0.2 to 25 $\mu$. Several new absorption bands were observed in the infrared part of spectrum. The effect of thermal and optical bleaching on the ultraviolet and infrared bands, which were induced by irradiation, was studied. The irradiations and measurements in the wavelength region from 0.2 to 2.5 $\mu$ were also performed at liquid air temperature. Furthermore, the effect of optical bleaching on the bands observed at low temperatures was investigated. (auth) (FINLAND)

**13968** PULSE RADIOLYSIS STUDIES OF ION ASSOCIATION. Beaumond, D.; Rodgers, M. A. J. (Univ. of Manchester, Eng.). Trans. Faraday Soc.; 65: 2973-80(Nov 1969).

Kinetic spectrophotometry has been used to follow the ion association process between benzophenone radical anions and alkali metal cations, in low dielectric media. This process was found to be diffusion-controlled. The spectral shifts induced by the nearby metal cations indicate that the larger cations form contact ion-pairs, whereas $Li^+$ and $Na^+$ form solvent-separated species, in which the anion partly penetrates the cationic solvent shell. (auth) (UK)

**13969** REACTION OF ATOMIC CARBON WITH FLUOROCARBONS. Blaxell, David; MacKay, Colin; Wolfgang, Richard (Yale Univ., New Haven). J. Amer. Chem. Soc.; 92: 50-5(14 Jan 1970).

The reactions of atomic carbon with fluorocarbons and $SF_6$ were studied using $^{11}C$ recoiling from nuclear reactions. No convincing evidence was found for insertion into C–F bonds, in contrast to the situation with alkanes, for which C insertion into the C–H bond is the most prominent reaction. Nevertheless the reactivity of fluorocarbons is quite comparable to that of hydrocarbons. All data are consistent with the hypothesis that the favored reaction of atomic carbon with perfluoroalkenes and $SF_6$ is formation of CF. With perfluoroalkenes the spectrum of perfluorocarbons formed is consistent with the expectation that insertion into the double bond occurs as it does in alkenes. Both hot and thermal carbon atoms undergo these reactions but the thermalized species is less reactive. It is suggested that atomic carbon, as an electron deficient species, preferentially attacks at sterically accessible points where electrons are most readily available. This hypothesis naturally accounts for observed addition to double bonds, insertion into C–H bonds, abstraction from C–F linkages, and the relative inertness of C–C bonds. (auth)

**13970** CHEMICAL EFFECTS ASSOCIATED WITH $\beta^-$ EMISSION. IV. DEFECTS PRODUCED IN $GeO_2$ BY IRRADIATION AND EFFECTS ON THE CHEMICAL STATE OF RADIOARSENIC FORMED BY $\beta^-$ EMISSION. Genet, Michel (Institut de Physique Nucleaire, Paris). Radiochim. Acta; 12: 193-9(Dec 1969). (In French).

The irradiation of $GeO_2$ with gamma rays or in a nuclear reactor as well as the thermal treatment of the oxide was studied by several experimental techniques. The presence of tracer quantities of water (1 to 2%) extinguished the EPR signal observed in irradiated $GeO_2$ and contributed to its disappearance when the oxide was thermally annealed. In the dehydrated oxide the intensity of the EPR signal was much stronger and its extinction by thermal annealing therefore required a higher temperature. The EPR signal is linked to the presence of radicals in irradiated GeO which reduce the dissolved oxygen upon dissolution of the oxide and thus give rise to the formation of hydrogen peroxide. The groups present in irradiated $GeO_2$ result in the formation of divalent germanium at the moment of dissolution. A study of the chemical effects concerning the radioarsenic produced by the nuclear reaction in $GeO_2$ was completed. There is perfect synchronism between the oxidation of radioarsenic by thermal annealing of $GeO_2$ and the rate of extinction of the EPR signal. (auth)

**13971** REACTIONS OF ELECTRONS PHOTOEJECTED FROM AROMATIC AMINO ACIDS IN FROZEN AQUEOUS SOLUTIONS OF DIVALENT METAL SALTS. Santus, Rene; Helene, Annie; Helene, Claude; Ptak, Marius (Centre de Biophysique Moleculaire, Orleans, France). J. Phys. Chem.; 74: 550-61 (5 Feb 1970).

Aromatic amino acids (tryptophan, tyrosine) are ionized by ultraviolet radiation in frozen aqueous solutions containing various divalent salts. Their triplet → triplet and radical cation absorption spectra were recorded at 77°K. According to electron spin resonance studies, electron photoejection occurs via a triplet–triplet absorption process. Photoejected electrons react with $M^{2+}$ ions to give $M^+$ ions or with $H^+$ to give H atoms. The nature and number of electron traps depend on the salt, as deduced from temperature and light effects. In the presence of $CdCl_2$, photoejected electrons are trapped in many heterogeneous sites producing a broad ESR resonance. $Cl_2^-$ ions are also produced when chloride is present. There are great similarities in the effects of γ and uv radiations. When uv-irradiated frozen aqueous solutions of tryptophan containing $CdSO_4$ were further irradiated at longer wavelengths, translocation of trapped electrons was observed. Photobleaching with various wavelengths detects electrons trapped in wells of different depths. (auth)

**13972** RADIOLYSIS OF WATER VAPOR IN A WIDE RANGE RADIOLYSIS SOURCE OF A MASS SPECTROMETER. I. INDIVIDUAL AND TOTAL CROSS SECTIONS FOR THE PRODUCTION OF POSITIVE IONS, NEGATIVE IONS, AND FREE RADICALS BY ELECTRONS. Melton, Charles E. (Univ. of Georgia, Athens). J. Phys. Chem.; 74: 582-7(5 Feb 1970).

The abundance of, and the total and individual cross sections for, primary products (positive ions, neutral species, and negative ions) resulting from elementary reactions induced by the absorption of energy by $H_2O$ from ionizing radiation (100-eV electrons) were measured. This was accomplished with the dual-beam and high transmission ion sources in a mass spectrometer. Positive ions were produced in much greater abundance than free radicals, 67.3% vs 32.1%. Negative ions, on the other hand, were about three orders of magnitude less abundant than the other primary products. Results for positive ion were in good agreement with those reported by other workers with the exception of that for $H^+$, which differs by a factor of 3. No valid reason for the discrepancy could be found. However, the present value for the total ionization cross section of $2.2 \times 10^{-16}$ $cm^2$ $molecule^{-1}$ is in good agreement with that reported by other workers. No previous values for radicals are available with which to make comparisons. The results show that hydrogen radicals account for 54% of all neutral primary products while hydrogen molecules (produced by rearrangement) account for only 13%. On the basis of these results, hydrogen atoms play a dominant role in the radiolysis of water vapor. (auth)

**13973** RETENTION OF CONFIGURATION DURING RECOIL TRITIUM REACTIONS AT ASYMMETRIC CARBON POSITIONS IN 2,3-DICHLOROBUTANE. Tang, Yi-noo; Ting, C. T.; Rowland, F. S. (Univ. of California, Irvine). J. Phys. Chem.; 74: 675-7(5 Feb 1970).

A series of experiments were carried out to measure the retention-inversion characteristics of the recoil tritium substitution reaction with 2,3-dichlorobutane in all three phases. The 2,3-dichlorobutane samples were irradiated with neutrons or exposed to tritium from a $^3He$ source. (M.C.G.)

**13974** RADIATION-INDUCED CHAIN DECOMPOSITION OF HEXACHLOROETHANE IN CYCLOHEXANE SOLUTIONS. REACTIONS OF THE PENTACHLOROETHYL RADICAL. Horowitz, A.; Rajbenbach, L. A. (Soreq Nuclear Research Centre, Yavne, Israel). J. Phys. Chem.; 74: 678-81(5 Feb 1970).

Irradiation of dilute solutions of hexachloroethane in cyclohexane was carried out to generate pentachloroethyl radicals by the reaction of radiolytically generated cyclohexyl radicals with the solute. The activation energy of the monomolecular elimination of the chlorine atom from the pentachloroethyl radical was found to be 16.9 kcal $mol^{-1}$. (M.C.G.)

**13975** THERMOLUMINESCENCE OF THE OLEUM CALAMI LUMINOPHOR IN ALCOHOL. Kucharski, Jan (Engineering Coll., Bialystok, Poland). Nukleonika; 14: 555-62(1969).

Alcoholic solutions of the essential calamus oil luminophor were found to glow after irradiation with uv- or x-rays at low temperatures. As the temperature of the luminophor is raised, the intensity of "phosphorescence" increases and attains a maximum, upon which it diminishes with the further increase of temperature. (auth)

**13976** PRODUCTION OF CARRIER-FREE RADIOISOTOPES FROM TARGETS IRRADIATED WITH DEUTERONS OR α-PARTICLES IN THE U-120 KRAKOW CYCLOTRON. I. PREPARATION OF CADMIUM, INDIUM, AND TELLURIUM RADIOISOTOPES. Kopta, Stefan; Niewodniczanski, Henryk; Petryna, Tadeusz; Stronski, Ignacy (Inst. of Nuclear Physics, Krakow). Nukleonika; 14: 619-26(1969).

The results of experiments on the preparation of carrier-free radioisotopes from targets irradiated in a U-120 cyclotron are presented. In the Ag(d,2n), Ag(α,xn), and Sn(α,xn) reactions the isotopes $^{109}Cd$, $^{109}In$, $^{110m}In$, $^{111}In$, $^{119}Te$, $^{119m}Te$, $^{121}Te$, and $^{121m}Te$ prepared by ion exchange, extraction, and precipitation were obtained. (auth)

**13977** RADIOLYSIS OF CYCLOHEXANE WITH PERFLUOROCYCLOHEXANE AT VERY HIGH DOSE RATES. Sagert, N. H. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can J. Chem.; 48: 501-3(1 Feb 1970). (AECL-3496).

The radiolysis of liquid cyclohexane using perfluorocyclohexane as an electron scavenger was examined at very high dose rates. The dose rates, $10^{27}$ to $10^{28}$ eV/g s, were such that geminate recombination of ions was essentially unaffected by dose rate, but high concentrations of radicals were produced, leading to radical–radical reactions. Up to 0.7 G units of the mixed dimer, $C_6F_{11} \cdot C_6H_{11}$, were produced indicating that large concentrations of $C_6F_{11}$ radicals are formed in the neutralization process. Thus, at conventional dose rates ($10^{16}$ eV/g s), $C_6F_{11}H$ is probably produced by reactions of $C_6F_{11}$ radicals rather than by proton transfer to a perfluorocyclohexane or perfluorocyclohexyl anion. (auth) (Canada)

**13978** THE INITIAL DISTRIBUTION OF $^{32}P$-ACTIVITY IN NEUTRON-IRRADIATED SALTS OF PHOSPHORUS-OXYACIDS. Fenger, J. (Atomic Energy Commission Research Establish-

ment, Risoe, Denmark). Radiochim. Acta; 12: 186-92(Dec 1969).

Twenty-eight ammonium and alkali-metal salts of phosphorus oxyacids were neutron irradiated at liquid-nitrogen temperature. An approach to the initial distribution of $^{32}P$ was obtained by immediate dissolution of 0°C and analysis by paper electrophoresis. It is shown that at least fourteen different anions labeled with $^{32}P$ can be formed; neither cations nor volatile species were observed. The results are best understood in terms of a model in which the skeletons of polymer species are formed in hot reactions and in which there is little fragmentation in the reaction zone. (auth)

**13979** ELECTRON SPIN RESONANCE STUDY OF γ-IRRADIATED DIPOTASSIUM DIFLUOROMALONATE MONOHYDRATE. Herring, F. G.; Lin, W. C.; Mustafa, M. R. (Univ. of British Columbia, Vancouver). Can. J. Chem.; 48: 447-50(1 Feb 1970).

The γ irradiation of dipotassium difluoromalonate monohydrate led to the formation of two molecular configurations of the $\dot{C}F_2CO_2^-$ radical in addition to the previously identified $\dot{C}F(CO_2^-)_2$ radical. A comparison of the α-fluorine coupling in the two forms of the $\dot{C}F_2CO_2^-$ radical indicated that loss of a carboxylate group nearly coplanar with the C–C–C plane in the undamaged molecule is favored. (auth) (Canada)

**13980** COMPARISON OF ALPHA- AND GAMMA-RAY RADIOLYSIS OF THYMINE. Drasil, V.; Ryznar, L. (Inst. of Biophysics, Brno). pp 17-25 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

The radiolysis of thymine with $^{218}Po$ alpha particles shows that qualitatively the same products of radiolysis are formed as with x or gamma rays. In the presence of oxygen, thymine hydroperoxide and thymine glycols are the main products of radiolysis with alpha rays. The amount of thymine hydroperoxide is about 30% of all products formed. In the absence of oxygen, thymine glycols, dihydrothymine, and its monohydroxyderivatives and 5-hydroxymethyluracil are formed. These results prove that the OH radical is the main species taking part in the alpha radiolysis of thymine. The presence of dihydrothymine and its derivatives shows the H atom to take part also in the splitting of thymine by alpha particles. Among other products of alpha radiolysis there is a higher percentage of urea and 5-hydroxymethyluracil if compared with gamma rays. (auth)

**13981** STABLE AND TRANSIENT SPECTRA IN PULSE IRRADIATED METAPHOSPHATE GLASSES. Rabani, J.; Ottolenghi, M. (Hebrew Univ., Jerusalem). Israel J. Chem.; 7: 605-11 (1969).

Pulse radiolysis of pure metaphosphate glasses yields a transient spectrum with a maximum at 580 nm. This new absorption overlaps that of the permanent coloration of 500 nm. The decay of the 580 nm species extends over a very large time interval, from $\sim 10^{-7}$ sec to $\sim 10^{-2}$ sec. The effects of doping the glass with $CdSO_4$ and $Ce_2(SO_4)_3$ are reported and analyzed. The results are interpreted in terms of various electron and hole centers. It is suggested that nonhomogeneous (spur or cage) kinetics is responsible for the 580 nm decay. (auth)

**13982** INVESTIGATIONS ON THE PRIMARY PROCESSES IN GASEOUS HYDROGEN SULFIDE WITH THE HELP OF PULSE RADIOLYSIS. Perner, D.; Franken, Th. (Institut fuer Physikalische Chemie, Juelich, Ger.). Ber. Bunsenges. Phys. Chem.; 73: 897-901(Nov 1969). (In German).

The main reactions of the shortlived intermediates produced in gaseous $H_2S$ by pulse radiolysis have been followed directly or indirectly by kinetic absorption spectroscopy in $H_2S$ or mixtures of $H_2S$ with additives. Following these reactions a mechanism for the decomposition of $H_2S$ has been evaluated. The rate constants $k_{H+H_2S}$ and $k_{SH+SH}$ were found to be $(7.7 \pm 1.5) \times 10^8$ l mole$^{-1}$ sec$^{-1}$ and $(3.2 \pm 0.3) \times 10^{10}$ l mole$^{-1}$ sec$^{-1}$, respectively. Absolute rate constants have been determined for the reaction of the SH radical with 1,3-butadiene, 1,4-cyclohexadiene, allene, cyclohexene, chloroethylene, ethylene oxide, acetylene, 1-butene, benzene, and $H_2S_2$. (auth)

**13983** RADIATION AFTER-BRIDGING OF MOLDED POLYSTYRENE. Ito, Syoji; Onishi, Syunji (Research Inst. for POLYMERS AND Textiles, Yokohama, Japan). Sekiyu To Sekiyu Kagaku; 13: No. 11, 66-72(Nov 1969). (In Japanese).

Radiation after-bridging of molded polystyrene was carried out by soaking a polystyrene film in a mixture of methanol (weak solvent for polystyrene) and some monomer of the diene system. Gamma radiation, uv, or electron beams may be used as the radiation, and crosslinking proceeds at low doses and at ordinary temperatures. Divinylbenzene was not suitable as a bridging agent, but isoprene and butadiene showed possibility. It was found that the ratio of bridging agent to solvent must be closely controlled. When the ratio was small, the bridging took place only on the surface, and when the ratio was large, the molded product was damaged and the gel content was lowered. The limit of thickness of molded product in which bridging is possible was not established. (NSA of Japan)

**13984** RADIOINDUCED REACTIONS IN POLYTETRAHYDROFURAN. Langbein, W. (Deutsches Kunststoff-Institut, Darmstadt, Ger.). Kolloid-Z. Z. Polym.; 233: 885-90(Aug 1969). (In German).

Polytetrahydrofuran $[(CH_2CH_2CH_2CH_2O)_n]$ was irradiated at 14°C in vacuo by 1-MeV electrons at a dose rate of 10 Mrad/min from a Van de Graff generator. The radioinduced reactions were studied by measurements of the gel fraction, by ir spectroscopy, and gas chromatography. The G values for the formation of various products are tabulated. Comparison of the results with the radioinduced reactions in polyethylene oxide, polyoxymethylene, and polyethylene shows that in all these polyethers similar reactions occur. Their probabilities depend on the fraction of C–O, C–H, and C–C bonds. In particular, radiation stability decreases in proportion to increasing C–O fraction. Under the conditions used, polyethylene was altered the least and polymethylene the most by energetic irradiation. (BBB)

## Radiochemistry

*Refer also to abstract 14479.*

**13985** TRACE COLLOIDS /RADIOCOLLOIDS/ AND THE INTERACTION OF TRACE ELEMENTS IN AQUEOUS SOLUTIONS. Benes, P.; Majer, V. (Technical Univ., Prague). Radiochem. Radioanal. Lett.; 2: 359-64(31 Dec 1969).

A new term "trace colloids," which accounts for the special properties and nature of colloids of both radioactive and stable trace elements, is suggested. The present state of theories of radiocolloids and the probable role of interaction between trace elements in the processes of formation of the colloidal solid phase are discussed. A preliminary communication concerning the experimental investigation of the interaction in the system Y and Fe(III) traces in aqueous solutions is given. (auth)

**13986** REACTIONS OF ACCELERATED TRITIUM IONS IN BENZENE–NAPHTHALENE MIXTURES. Firsova, L. P.; Tyung, Do Kim. Radiokhimiya; 11: 587-92(1969). (In Russian).

The radiochemical yields of labeled substances, formed on irradiation of benzene–naphthalene mixtures by 2.5-kV tritium ions, were determined. (M.C.G.)

**13987** PROMPT EMANATION OF ASTATINE AND RADON. Grover, J. Robb; Lebowitz, Elliot; Baker, Elizabeth (Brookhaven National Lab., Upton, N. Y.). J. Inorg. Nucl. Chem.; 31: 3705-20(Dec 1969).

Prompt and copious emanation of 0.032-sec $^{217}At$ has been observed from lanthanum sterate and of 0.035-sec $^{218}Rn$ from both uranyl and lanthanum sterates. At room temperature the emanating power for $^{217}At$ is about 0.2$_3$, and for $^{218}Rn$ about 0.4$_3$. The data give the first published information on the emanation of astatine from a soap, and show a convenient way to prepare a volatile compound of astatine. Sticking coefficients for several materials, and as a function of temperature suggest strongly that the emanating species is HAt. From the temperature dependence of radon emanation in vacuum the prompt (temperature-independent) component was found to be larger than previously observed in experiments at atmospheric pressure. At room temperature >65 per cent of the emanated $^{218}Rn$ is prompt, and escapes from the solid phase in <0.01 sec. (auth) (UK)

**13988** URAN-234. ($^{234}U$). Cherdyntsev, V. V. Moscow; Atomizdat (1969). 308p.

Results of investigations of the properties and behavior in nature of $^{234}U$ are summarized. The separation of isotopes of natural uranium by a specific mechanism, the Szillard–Chalmers effect, is discussed. Use of nonequilibrium uranium in the earth's core for investigation of the geology of ore deposits, quaternary geology, oceanography, volcanology, determination of the absolute age of young formations, archeology, and other studies are described. Nuclear properties of uranium isotopes, the history of radioelements in space and the earth's core, and conditions for separation of radioactive isotopes and elements are considered. The main problems in nuclear geochemistry and the material on the behavior of $^{234}U$ in natural processes are presented. (tr-auth)

**13989** SOVREMENNAYA RADIOKHIMIYA. (Up-to-date Radiochemistry). Vdovenko, V. M. Moscow; Atomizdat (1969). 544p.

A brief review of the history and development of radiochemistry in Russia is offered. General problems of radiochemistry and methods used in radiochemistry are discussed. The physicochemical properties of radioactive elements (Tc, Pm, Po, At, Rn, Fr, Ra, Ac, Th, Pa, U, Np, Pu, Am, Cm, Cf, Es, Fm, Md, Element 102, Lr, Element 104, and Element 105) are covered. The problems of applied radiochemistry in nuclear energy and chemistry of nuclear fuels are discussed. Applications of radioactive isotopes in technology, in particular, as sources of current, radiochemistry in oncological studies, and radioactive nuclides in external environment and waste disposal are also included. (125 references) (R.V.J.)

**13990** ABSOLUTE DETERMINATION OF THE SPECIFIC ACTIVITY OF SUBSTANCES CONTAINING $^{35}S$. Modes, D.; Becher, K.; Grosse, H.-J.; Schindler, G.; Roesseler, M. (Institut fuer Angewandte Radioaktivitaet, Leipzig). Isotopenpraxis; 5: 393-8(Nov 1969). (In German).

The most important conditions for the precise absolute determination of the specific activity of substances containing $^{35}S$ were studied: the $SO_2$ sorption on the counter and the filling apparatus, the influence of negatively charged $SO_2$ ions on the discharge mechanism in the region of limited proportionality, and kinetic isotope effects for incomplete change of the initial substance into gas to be measured. In particular, the change of sodium sulfate and sulfuric acid in aqueous solution and thiourea into barium sulfate and its combustion to sulfur dioxide are described. The total error of the specific activity readings for the initial substances mentioned above is given. (auth)

## Separation Processes

*Refer also to abstracts 13728, 13744, 13745, 13765, 13768, 13822, 13851, 13866, 13874, 13891, 13988, 14146, 16219, and 16316.*

**13991** (ANL-7614) THE EBR-II SKULL RECLAMATION PROCESS. PART IV. PILOT-PLANT DEVELOPMENT. Winsch, Irvin O.; Pierce, R. Dean; Grosvenor, David E.; Burris, Leslie Jr.; Cannon, Thomas F.; Mack, Paul J.; Nishio, Kazuo; Tobias, Kenneth R. (Argonne National Lab., Ill.). Sep 1969. Contract W-31-109-eng-38. 25p. Dep. CFSTI.

A pyrochemical process was developed for the recovery of enriched uranium from crucible skulls that result from the Experimental Breeder Reactor II (EBR-II) melt-refining process. Melt refining has been used in the EBR-II Fuel Cycle Facility to recover uranium from spent fuel discharged from the reactor. The complementary process for reclaiming uranium from crucible skulls, the skull-reclamation process, involves: oxidation of the skulls to liberate them from the crucible as a free-flowing powder; addition of the powder to a halide salt, and extraction of 75 to 95% of the nobler fission-product elements from the oxide with liquid zinc at 800°C; reduction of the uranium oxide to uranium metal by contacting the salt with a Mg-20 at.% Zn alloy at 800°C; removal of 95% or more of the remaining fission products by transferring away the molten salt and the metal alloy in which the metallic uranium is insoluble; dissolution of the uranium in a Zn-30 at.% Mg alloy; and recovery of the uranium product by retorting and melting. (auth)

**13992** (BNL-50184) DECONTAMINATION OF MELTER OFF-GAS CONDENSATES FROM THE PHOSPHATE GLASS PROCESS BY DISTILLATION. Drager, R. F.; Johnson, R. W.; Hatch, L. P. (Brookhaven National Lab., Upton, N. Y.). Mar 1969. 15p. Dep. CFSTI.

In the solidification of high level radioactive (Purex) wastes by the phosphate glass process developed at BNL, melter off-gas condensates are produced which consist mainly of nitric acid, sulfuric acid (with the use of ferrous sulfamate in the solvent extractions), phosphoric acid, and volatilized and entrained fission products, notably ruthenium. Separation and decontamination of the nitric acid and sulfuric acid components by means of vacuum distillation were investigated. The highest degree of decontamination was obtained at the lowest pressure and temperature. In laboratory-scale, single-distillation experiments maximum decontamination factors of $4.3 \times 10^3$ and $2.2 \times 10^4$ were achieved for the nitric acid and the sulfuric acid fractions at 3 mm Hg pressure. Satisfactory separation of both acid fractions was accomplished in laboratory-scale and bench-scale operation. On the basis of results obtained in preliminary corrosion tests, tantalum was found to be a suitable material of construction for the distillation equipment. The use of reducing agents such as hypophosphorous acid, $SO_2$, NO, and $NO_2$ was also investigated as a means of minimizing ruthenium volatilization during distillation at atmospheric pressure. (auth)

**13993** (BNWL-1185) WASTE SOLIDIFICATION PROGRAM. VOLUME 5. PHOSPHATE GLASS SOLIDIFICATION PERFORMANCE DURING FIRST RADIOACTIVE TESTS IN WASTE SOLIDIFICATION ENGINEERING PROTOTYPES. McElroy, J. L.; Hartley, J. N.; Schneider, K. J.; Drager, R. F. (Batielle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 138p. Dep. CFSTI.

Solidification of high level radioactive waste by the Brookhaven National Laboratory phosphate glass process was successfully demonstrated by Battelle-Northwest. More than 7 million curies of radionuclides were processed and collected in 8- and 12-inch-diameter containers during six engineering-scale demonstration runs in WSEP at the Pacific Northwest Laboratory. Radioactivity processed was increased from 350,000 curies in the first run to 2,400,000 curies in the sixth run. The solidified waste within a full 8-inch diameter pot represented 1.3 tonnes of power reactor fuel (irradiated at 20,000 MWd/tonne at a power level of 15 MW/tonne) for sulfate-containing PW-2 waste and 0.64 tonnes for sulfate-free PW-1 waste. High level aqueous radioactive waste was processed at overall rates of 9.4 to 18 liters/hr. From 2 to 10% of the total ruthenium fed to the solidifier was volatilized and/or entrained from the solidifier; entrainment of nonvolatiles varied from 0.2 to 0.3%. Volatilized and entrained material from the denitrator was further treated in the WSEP auxiliary process equipment, while the volatilized and entrained material from the melter was collected in a separate condensate receiver. The WSEP auxiliary equipment reduced radionuclides in the stack gas to well below 10CFR20 release limits. The radionuclide content in the final liquid effluent was decontaminated by a factor of $10^8$ for nonvolatiles and $10^6$ for radioruthenium to concentrations acceptable for low-level treatment processes. The phosphate glass solid caused no significant pressure increases within the containers after they were capped and welded. (auth)

**13994** (DOCKET-50201-29) [WEST VALLEY REPROCESSING PLANT]. License No. CSF-1. Technical Specifications, Modification of the Proposed Change No. 11. (Nuclear Fuel Services, Inc., West Valley, N. Y.). 10 Feb 1970. 57p. Dep. CFSTI.

Proposed changes to the technical specifications for form of materials, calibrations and standards, radioactivity content of liquid effluents, fissile isotope concentration in solvent extraction, rework solution concentration, and administrative requirements are given. (M.C.G.)

**13995** (DOCKET-50268-4) MIDWEST FUEL RECOVERY PLANT. Design and Analysis, Suppl. 2. (General Electric Co., San Jose, Calif. Nuclear Energy Div.). 2 Feb 1970. 18p. Dep. CFSTI.

An investigation was made of tornado missiles and their effect on critical portions of the Midwest Fuel Recovery Plant along with studies of the effects of earthquakes on the low-activity waste vault tank. (M.C.G.)

**13996** (KFK-996) INVESTIGATION OF THE ACCOUNTABILITY TANK OF REPROCESSING FACILITY. Roth, B. F.; Lindner, W.; Fischer, P. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Heisse Chemie). Oct 1969. 70p. (In German). Dep. CFSTI (U. S. Sales Only).

Calibration and operation values were determined for use in construction of the accountability tank. Calibration of a ring container using an ascending tube is described, along with volume determination by the air bubble method. Investigations were made of the ejector diffusion pump. (M.C.G.)

**13997** (ORNL-4120) HOT-CELL EVALUATION OF THE BURN-LEACH METHOD FOR REPROCESSING IRRADIATED GRAPHITE-BASE HTGR FUELS. Vaughen, V. C. A.; Flanary, J. R.; Goode, J. H.; Witte, H. O. G. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 63p. Dep. CFSTI.

The combustion of graphite-base HTGR fuel with an oxygen-nitrogen mixture at 750°C in a fluidized bed of alumina is a process marked by good temperature control and ease of operation. This process was evaluated in hot-cell tests using prototype fuels irradiated to a burnup of up to 41,500 Mwd/ton and cooled more than two years. Each fuel sample consisted of a graphite matrix containing pyrolytic-carbon-coated $(Th,U)C_2$ particles. The product was a free-flowing powder of finely divided $ThO_2-U_3O_8$-fission product oxide particles in the alumina. The combustion off-gases carried considerable quantities of carbon fines, highly radioactive fly ash, volatile fission product oxides, and gaseous fission products out of the fluidized bed. In hot-cell tests, all except the noncondensable contaminants in the off-gas were effectively trapped by a sintered metal filter when the temperature of the off-gas was

less than 300°C at the filter. This filter, which had a porosity of 20 μ and was dust coated, was backed by a deep-bed fiberglass filter. The off-gas was decontaminated to less than the Maximum Permissible Concentration ($MPC_a$) by secondary filtration. Recoveries of 99.8% of the uranium and 99.3% of the thorium from the alumina-ash bed were achieved (with alumina recycle) by leaching in boiling Thorex reagent (13 M $HNO_3$–0.1 M $Al(NO_3)_3$–0.05 M HF). About 6% of the gamma-emitting nuclides, primarily ruthenium and antimony, were retained by the alumina. The economics of the process can be improved by recycling the alumina. A flowsheet was evaluated in which the amount of alumina to be leached prior to recycling was reduced to 20 to 50% of the total when the ~40-μ-diam $U_3O_8$–$ThO_2$ ash particles were separated from the ~200-μ-diam alumina. (auth)

**13998** (ORNL–4400, pp 31-56) BEHAVIOR OF FISSION PRODUCTS AND PROTACTINIUM IN MOLTEN FLUORIDES. (Oak Ridge National Lab., Tenn.).

Progress is reported on: particles in and above molten salts, synthesis of noble metal fluorides and identification of species in and above molten fluorides, and reprocessing studies for molten-salt breeder reactors. (M.C.G.)

**13999** (ORNL–4400, pp 134-41) BEHAVIOR OF ELEMENTAL AND COMBINED IODINE. (Oak Ridge National Lab., Tenn.).

Studies are reported on: samplers for characterization of iodine, removal of molecular forms of iodine from moist-air systems, radioiodine trapping in off-gas systems of fuel reprocessing plants, reactions of iodine vapor in containment systems, reactions of methyl iodide with chemical spray solutions, and uptake of methyl iodide by water solutions and drops. (M.C.G.)

**14000** (RLO–1750-54, pp 19) APDC EXTRACTION EFFICIENCY FOR VARIOUS TRACE RADIONUCLIDES. Forster, William O.; Wagner, Jerry (Oregon State Univ., Corvallis. Dept. of Oceanography).

The extraction efficiency of ammonium pyrrolidine dithiocarbamate for Cr, Sc, Mn, Fe, Co, Zn, and Sb was studied. (M.C.G.)

**14001** (UCRL-Trans–10426) PROPERTIES OF THE DOWEX A-1 AMINO ACETIC SALT RESIN. II. RELATIVE AFFINITIES OF THE RESIN WITH SEVERAL CATIONS. Rosset, Robert. Translated for Univ. of California Lawrence Radiation Lab., Livermore, from Bull. Soc. Chim. Fr.; No. 1, 59-66(1966). 15p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 20: 16358.

**14002** SYNERGISTIC PECULIARITIES IN THE EXTRACTION OF URANIUM FROM SOLUTIONS OF NITRIC ACID BY EQUIMOLAR MIXTURES OF D2EHPA AND TBP IN KEROSENE. Bykhovtsev, V. L.; Melikhova, G. N. Radiokhimiya; 11: 619-20 (1969). (In Russian).

Equimolar mixtures of DEHPA and TBP extract uranium from nitric acid solutions synergistically. Data are presented in a table. (M.C.G.)

**14003** INVESTIGATION OF THE EXTRACTION OF DIFFERENT ACTINIDE ELEMENTS BY N,N-DIALKYLACETAMIDES FROM NITRATE SOLUTIONS. Shmidt, V. S.; Sokolov, V. S. Radiokhimiya; 11: 593-5(1969). (In Russian).

It is shown that neptunium(IV) and (VI) and plutonium(IV) and (VI) are extracted from nitrate solutions by N,N-didodecylacetamide. The relations of the coefficients of distribution of Np and Pu between nitrate solutions and N,N-diheptyl- or N,N-didodecylacetamide to the nitric acid concentration were determined. (M.C.G.)

**14004** EXTRACTION OF URANYL NITRATE BY N,N-DIALKYLACETAMIDE. Sokolov, V. S.; Teterin, E. G.; Shesterikov, N. N.; Shmidt, V. S. Radiokhimiya; 11: 535-44 (1969). (In Russian).

The extraction of uranyl nitrate by solutions of N,N-dioctylacetamide, N,N-didecylacetamide, or N,N-didodecylacetamide with additions of aliphatic alcohols was studied. It was established that uranyl nitrate forms complexes with these amides with the composition $UO_2(NO_3)_2 \cdot 2$ amide. These complexes were isolated in the solid form and their properties studied. It was found that the reaction of the amides with uranyl nitrate occurs through the oxygen of the carbonyl group. (M.C.G.)

**14005** SEPARATION OF ZIRCONIUM AND HAFNIUM FROM OTHER ELEMENTS BY ADSORPTION ON SILICA GEL FROM MIXED SOLUTIONS. Tsaiotka, R.; Zaitseva, T. D. Radiokhimiya; 11: 510-15(1969). (In Russian).

The possibilities of separation of micro and macro amounts of zirconium and hafnium from all other elements in mixed aqueous–organic solutions of hydrochloric acid were studied. The sorbent used was silica gel. It was found that replacement of part of the water in the solution with methanol or ethanol increased the coefficient of distribution of the zirconium and hafnium. (tr-auth)

**14006** EXTRACTION OF NIOBIUM AND TANTALUM FROM HYDROCHLORIC ACID SOLUTIONS BY AMINES. Alimarin, I. P.; Gibalo, I. M.; Ivanov, N. A.; Sanaeva, E. A. Radiokhimiya; 11: 515-20(1969). (In Russian).

Experimental data are presented on the extraction of niobium and tantalum from hydrochloric acid solutions by dioctylamine and triisopentylamine. The distribution of niobium and tantalum was studied under equilibrium conditions at 20 ± 1°C. The effects of different variables were studied. (M.C.G.)

**14007** INFLUENCE OF MOLECULAR ASSOCIATION OF AMINE SALTS ON THE EXTRACTION OF METAL SALTS BY THESE EXTRACTION AGENTS. Shmidt, V. S.; Mezhov, E. A. Radiokhimiya; 11: 520-4(1969). (In Russian).

Previously, it was shown that the mechanism of extraction of microconcentrations of metal salts by amine salts can be described by the equations: $m(AmineHA)_s + MA_x = [(AmineHA)_{n-1}AmineH]_m - MA_{x+m}$ (where n is the degree of association of amine salts in the organic phase, M is the cation of the extracted metal, and A is the anion salt ($MA_x$) of the metal. Quantitative extraction of $CoCl_2$ from chloride solutions was achieved using tris(decyl)-amine and tridodecylamine chlorides. The quantitative rules in extraction of $Th(NO_3)_4$ from nitrate solutions by tris(decyl)amine and tridodecylamine nitrates comply with the postulate stating that the extracted compounds have the composition $[(AmineHNO_3)_{n-1}AmineH]_2\,Th(NO_3)_k$, where n is the degree of alkylamine nitrate association in the organic phase. (R.V.J.)

**14008** RAPID ISOLATION OF INDIVIDUAL RARE EARTHS FROM FISSION AND IDENTIFICATION OF $^{152}$Nd. Wakat, A.; Griffin, C. (Univ. of Michigan, Ann Arbor). Radiochem. Radioanal. Lett.; 2: 351-7(31 Dec 1969).

The application of ion exchange chromatography to the isolation of short-lived fission product rare earths has been demonstrated through studies of Nd and Pm produced by the fission of $^{235}$U. A new isotope of Nd, 11.3-min $^{152}$Nd, has been identified, and decay characteristics of its daughter, 4.1-min $^{152}$Pm, have been determined. (auth)

**14009** SEPARATION OF NIOBIUM AND PROTACTINIUM BY AMALGAMATION. Vernois, J.; Mordant, G.; Muxart, R. (Institut de Physique Nucleaire, Arcueil, France). Radiochem. Radioanal. Lett.; 2: 327-32(31 Dec 1969). (In French).

Niobium and protactinium in lithium citrate solution were separated from each other by electrolysis using a lithium amalgam cathode. (auth)

**14010** SOME RESULTS ON THE REMOVAL OF RADIOCESIUM FROM LOW-ACTIVITY WASTE WATER BY COPRECIPITATION WITH FERROCYANIDES. Friedmann, Ch.; Schoenfeld, T. (Institute for Radiation Protection, Seibersdorf, Austria. Univ., Vienna). Radiochem. Radioanal. Lett.; 2: 333-41(31 Dec 1969).

Precipitation of $^{137}$Cs with small amounts of cupric and ferric ferrocyanides from actual waste water was investigated. The results indicated that if moderate decontamination factors, 30 to 50, suffice, reagent quantities smaller than those now in use at various plants for the treatment of low-activity waste can be employed. (auth)

**14011** GAS-PHASE DIFFERENTIAL ADSORPTION CONTINUOUS PURIFICATION PROCESS. (to Commissariat a l'Energie Atomique). British Patent 1,177,794. 14 Jan 1970. Priority date 19 Jan 1966, France.

A process for the continuous enrichment or purification of a constituent of a gaseous mixture by differential adsorption comprises continuously supplying the gaseous mixture to a column filled with a granular solid impregnated with a liquid. The granular solid moves by a pneumatic conveying system countercurrent to the gaseous mixture in the column; and the gaseous mixture passes successively from top to bottom of the column through an adsorption zone, a rectification zone, an exhaust zone, and a cooling zone before being reintroduced continuously at the top of the column. The gaseous mixture is supplied to the lower part of the column above the cooling zone. The most volatile components are collected at the head of the column above the absorption zone, and the least volatile components are collected at the lower part of the column above the exhaust zone. (B.L.M.)

**14012** EXTRACTION OF MOLYBDENUM(VI) BY PROPYLENE CARBONATE. Murata, Katsuo; Ikeda, Shigero (Osaka Univ.). J. Inorg. Nucl. Chem.; 32: 267-75(Jan 1970).

A condensed molybdate complex was extracted from acidic solu-

tions of pH 0.5 to 5 by propylene carbonate ($PrCO_3$). The extracted complex exhibited a yellow color and had three characteristic absorption maxima at 225 mμ, 260 mμ, and 325 mμ. The extraction data indicated that the extracted species was highly condensed and adducted three propylene carbonate molecules. Propylene carbonate behaves not only as an extracting reagent but also as the reagent which reacts with molybdate in adequate acidic solution to produce the extractable species. (auth) (UK)

**14013** ANALOGOUS ACTINIDE(III) AND LANTHANIDE(III) TETRAD EFFECTS. Peppard, D. F.; Bloomquist, C. A. A.; Horwitz, J.; Lewey, E. P.; Mason, G. W. (Argonne National Lab., Ill.). J. Inorg. Nucl. Chem.; 32: 339-43(Jan 1970).

The hypothesis: "in liquid-liquid extraction systems involving all 15 lanthanides (III) the points on the log K vs Z plot may be grouped, through the use of four smooth curves without inflections into four tetrads with the Gd point common to the second and third tetrads and the extended smooth curves intersecting in the 60-61 and 67-68Z regions," was tentatively generalised, in the hope of promoting interest in an explanation, by addition of "in a similar plot for actinides (III) an analogous tetrad effect is apparent with the Cm point common to the second and third tetrads." Conformative data for lanthanides (III) and actinides (III) in liquid-liquid extraction systems and in partition chromatography systems are presented and interpreted in terms of tetrads. A literature test of the validity of the tetrad hypothesis was inconclusive; the results of a number of widely differing types of investigations, however, lend support, and a few are quoted, including ion exchange, heats of vaporization, and sublimation recrystallisation temperature studies. The general tetrad hypothesis does not preclude the possibility of fission of two or more tetrads. Also, since a given "smooth curve without inflections may be a straight line, the hypothesis is consistent with a single straight line for the entire series of lanthanides (III) or actinides (III). (UK)

**14014** THEORETICAL TREATMENT OF THE ELUTION SYSTEM OF RARE-EARTH WITH DILUTE H.E.D.T.A. ELUANT. Hagiwara, Zenzi; Oki, Hideo (Tohoku Univ., Sendai). J. Inorg. Nucl. Chem.; 32: 291-307(Jan 1970).

The elution of a single rare earth from cation exchange resins was investigated by means of 0.015 M HEDT. A buffered solutions at pH-values ranging from 4.9 to 8.8. After the attainment of dynamic equilibrium in the exchange system by moving the rare earth band through the hydrogen-retaining bed, the constituents in the aqueous and resin phases of the formed bands were determined, and fundamental correlations of the experimental data were found. Theoretical treatments of all the species involved in the exchange system were made, applying material balance, electrical neutrality and other theories. Several theoretical curves were obtained in order to check the experimental data. The agreement was excellent. Major selectivity coefficients related to the exchange system were evaluated in detail. (auth)

**14015** DETERMINATION OF $^{239}Np$ FROM FALLOUT SAMPLES. Khandekar, R. N.; Santani, Smt. S. B. (Bhabha Atomic Research Centre, Bombay). Curr. Sci. (India); 39: 49-51(5 Feb 1970).

An analytical procedure is described for the separation of neptunium-239 from fallout samples. Neptunium is separated from uranium, plutonium, and fission products by a solvent extraction method. Np(IV) is extracted from 1M nitric acid by shaking with an equal volume of 0.5 M thenoyltrifluoroacetone (TTA) solution in xylene and back-extracted with 8 M nitric acid. Finally, Np is coprecipitated with zirconium mandelate, and counted in a low background beta-counting set-up. The average chemical recovery by this procedure is 82.6%. Under the conditions described, very good separation of neptunium is effected from alumimum, iron, fission products, thorium, uranium, and plutonium. (auth)

**14016** PROTSESSY I APPARATY URANOVYKH PROIZVODSTV. (Processes and Equipment at Uranium Production Units). Sudarikov, B. N.; Rakov, E. G. Moscow; Izdatel'stvo Mashinostroenie (1969). 384p.

Problems of selection and calculation of the equipment for refining and production of uranium from ore are analyzed. Hydrometallurgical processes including crushing, leaching, hydraulic classification, ion exchange sorption, extraction, precipitation, and filtration are covered in the first chapter. High-temperature processes and equipment, including kinetics of heterogeneous chemical reactions, drying, calcination, processes in plasma flame, reduction and refining of uranium are discussed in the second chapter. (R.V.J.)

**14017** DETERMINATION OF CONDITIONS OF THE CHROMATOGRAPHIC SEPARATION OF RARE EARTH ELEMENTS ON THE BASIS OF EQUILIBRIUM AND KINETIC DATA. Safonova, N. D.; Matorina, N. N.; Chmutov, K. V. (Inst. of Physical Chemistry, Moscow). Zh. Fiz. Khim.; 43: 2885-8(Nov. 1969). (In Russian).

Work was carried out to confirm the theoretical selection of conditions for chromatographic separation. Optimum pH values were calculated for separation of rare earths using 0.01M EDTA at 25 and 85°C. It was found that the best separation took place at 85°C. (M.C.G.)

**14018** SEPARATION AND PURIFICATION OF GALLIUM ISOTOPES BY EXTRACTION-CHROMATOGRAPHIC TECHNIQUE AFTER ELECTROMAGNETIC SEPARATION. Ad'yasevich, I. K.; Bel'skaya, E. P. At. Energ. (USSR); 28: 64-5(Jan 1970). (In Russian).

The extraction–chromatography method was used for the separation and purification of Ga from Fe and Cu impurities. The results showed that this method with ion exchange resulted in gallium oxide with 0.001% Cu and 0.01% Fe. The extraction method described can be used in the electromagnetic method for isotope separation. (R.V.J.)

**14019** EXTRACTION BEHAVIOR OF EUROPIUM WITH THENOYLTRIFLUOROACETONE (TTA). Ikeda, Nagao; Kimura, Kan; Asai, Hirokazu; Oshima, Nobuko (Tokyo Kyoiku Univ.). Radioisotopes (Tokyo); 19: 1-6(Jan 1970).

The distribution ratios of europium(III) were determined between chloroform containing thenoyltrifluoroacetone (TTA) and 0.1M aqueous perchlorate solution at 25°C, the TTA concentration in the organic phase and the hydrogen ion concentration in the aqueous phase being varied $10^{-4} \sim 10^{-1}$ M and $10^{-3} \sim 10^{-1}$ M, respectively. The distribution behavior was explained as the extraction of the tris chelate complex into the organic phase and as the formation of the chelate complexes, $EuA^{2+}$, $EuA_2^+$, and $EuA_3$ (A = anion of TTA) in the aqueous phase. Equilibrium constants were obtained graphically for the various equilibrium reactions. The distribution of Eu(II) was also studied. The distribution ratios for Eu(II) were smaller than those for Eu(III). It was suggested that the separation of Eu(II) from Eu(III) may be possible at pH $4.2 \sim 4.8$. (auth)

**14020** EXTRACTION OF THORIUM, NEPTUNIUM, AND PLUTONIUM FROM NITRIC ACID SOLUTION BY TBP SOLUTIONS CONTAINING URANIUM. Germain, M.; Gourisse, D.; Sougnez, M. (CEN, Fontenay-aux-Roses, France). J. Inorg. Nucl. Chem.; 32: 245-53(Jan 1970). (In French).

Partition coefficients of $Th(NO_3)_4$, $Np(NO_3)_4$, $NpO_2(NO_3)_2$, $Pu(NO_3)_4$, and $PuO_2(NO_3)_2$ were determined in the system TBP 30%, dodecane: $UO_2(NO_3)_2-HNO_3-H_2O$. The relative variations of the partition coefficients were attributed to the varying activity coefficients of the species both in the aqueous and the organic phase. In the acidity range investigated, $(HNO_3)_{aq} \leq 4.5N$, the results showed a striking similarity in the variation of activity coefficients corresponding to hexavalent elements; the tetravalent elements exhibited a rather intricate behavior and this made it difficult to draw any systematic conclusion. (auth) (UK)

**14021** RAPID SEPARATION OF RADIOACTIVE CESIUM BY NITROBENZENE EXTRACTION USING THE CHROMIUM COMPLEX $[Cr(aniline)_2(NCS)_4]^-$. Koyama, M.; Mitsuji, T.; Tochiyama, O.; Fujinaga, T. (Kyoto Univ.). J. Radioanal. Chem.; Chem.; 3: 413-20(Nov 1969).

A rapid separation of radioactive cesium by the solvent extraction method was investigated. Cesium ions are quantitatively extracted with $[Cr(NH_2C_6H_5)_2(NCS)_4]^-$ into nitrobenzene. EDTA is an effective masking agent for other polyvalent cations. The extracted cesium can be back-extracted into the aqueous phase by shaking with 6N HCl. The method was applied to samples of a natural mixture of fission products and a reactor coolant. The decontamination factors for other predominant isotopes in fission products were $10^2 \sim 10^4$. The separation of $^{137m}Ba$ from a mixture of $^{137}Cs$ and $^{137m}Ba$ is also described. (auth)

**14022** KINETICS OF DESORPTION OF HAFNIUM AND ZIRCONIUM FROM KY-2 CATION EXCHANGER. I. KINETICS OF DESORPTION OF HAFNIUM. Vinarov, I. V.; Grinberg, A. N. (Inst. of General and Inorganic Chemistry, Kiev). Zh. Fiz. Khim.; 43: 2894-8(Nov 1969). (In Russian).

Investigation of the desorption of hafnium from the KY-2 cation exchanger by 1N sulfuric acid showed that in the initial period this process takes place by interdiffusion and then is shifted into the mixed region. The temperature coefficients and activation energies for desorption of hafnium were calculated. (tr-auth)

**14023** DISPLACEMENT OF MOLYBDENUM FROM MOLTEN CHLORIDES BY METALLIC MANGANESE. Nichkov, I. F.; Popov, A. N.; Raspopin, S. P.; Chernyshev, V. V. (Ural Polytechnic Inst., Sverdlovsk, USSR). Izv. Vyssh. Ucheb. Zaved., Tsvet. Met.; No. 4, 74-7(1969). (In Russian).

The equilibrium constant of the reaction $2MoCl_3 + 3Mn \rightleftharpoons 2Mo + 3MnCl_2$, $lgK_p = 1.48 + 27759/T$, was calculated in molten NaCl–KCl. The completeness and rate of displacement of molybdenum did not depend on the temperature of the process. The displacement reaction proceeded rapidly (10 min at 730°C). (tr-auth)

**14024** CHARACTERISTIC OF SOME DIFFERENT COPRECIPITANTS USED IN CONCENTRATING OF NIOBIUM. Moroshkina, T. M.; Savinova, T. T. Vestn. Leningrad. Univ., Fiz., Khim.; No. 10, 127-9(May 1969). (In Russian).

The possibility is shown of concentrating niobium from solutions diluted $1:1\times10^6$ with various organic coprecipitants: phenolphthalein, β-naphthol, diphenylamine, thymolphthalein, and β-nitroso-α-naphthol. (auth)

**14025** STUDIES ON SEPARATION OF $^{22}Na$ FROM RADIOACTIVE SOLUTIONS BY MEANS OF DIFFERENT ADSORPTION MATERIALS. Lambrino, Vl.; Furnica, G. (Institutul de Medicina si Farmacie, Bucharest). Compt. Rend. Acad. Bulg. Sci.; 22: 1111-14(1969). (In French).

Separation and decontamination of the radioisotopes $^{85}Sr$, $^{134}Cs$, and $^{22}Na$ were compared. Very fine sand for the purification of water, sand washed with 10% HCl–10% $HNO_3$ solutions, industrial carbon, as well as sulfonic resins of Roumanian origin and bentonites were used to effect the separations. The most effective decontaminants for $^{85}Sr$ and $^{134}Cs$ were the bentonites and resins with 99.8 to 99.9% efficiency. Effective decontamination for $^{22}Na$ was possible only with the sulfonic resins (99%). (J.G.B.)

**14026** PREPARATION AND UTILISATION OF STANNIC PHOSPHATE AS AN ION EXCHANGER. De Bruyne, P. (Braine l'Alleud, Belgium). J. Inorg. Nucl. Chem.; 32: 346-7(Jan 1970). (In French).

The synthetic cation exchanger is stated to show great resistance to irradiation, and to be relatively stable in acid media, but unstable even in dilute alkaline solution. Details are given of the method of preparation of this material and of ion exchange columns using it, and its use in separating fission products from uranium and from each other is described. (UK)

**14027** EXTRACTION OF THORIUM NITRATE BY n-HEXANOL. Apelblat, A. (Nuclear Research Centre, Negev, Israel); Michaeli, I. J. Inorg. Nucl. Chem.; 32: 239-44(Jan 1970).

The uptake of $Th(NO_3)_4$ and water by hexanol at equilibrium with aqueous solutions of thorium nitrate was investigated. The experimental results were found to be consistent with a simple molecular model which assumes that thorium nitrate appears in the organic phase in the form of a single undissociated complex whose formula is $Th(NO_3)_4 \cdot 4C_6H_{13}OH \cdot 5H_2O$. (auth) (UK)

**14028** THE EXTRACTION OF MOLYBDENUM(VI) BY TRI-n-BUTYL PHOSPHATE. Cruywagen, J. J.; McKay, H. A. C. (Atomic Energy Research Establishment, Harwell, Eng.). J. Inorg. Nucl. Chem.; 32: 255-65(Jan 1970).

The extraction of molybdenum(VI) by tri-n-butyl phosphate from nitrate media at hydrogen ion concentrations between $10^{-3}$ and 0.3 M, was investigated. At low molybdenum concentrations ($<10^{-4}$ M) the principal species in the organic phase appears to be $Mo(OH)_6 \cdot HNO_3$. At higher molybdenum concentrations slow condensation reactions occur in both phases, and these can be followed by means of the changes in the molybdenum distribution coefficient. Pseudo first-order rate constants were determined. (auth) (UK)

**14029** RAPID CHEMICAL SEPARATIONS. Herrmann, Guenter; Denschlag, Hans Otto (Univ., Mainz). Ann. Rev. Nucl. Sci.; 19: 1-32(1969).

Topics covered include: demands on rapid radiochemical separations, exemplary approaches, separations from solid and molten targets, separations from aqueous solutions, separations from gaseous targets, and applications of rapid chemical separations in nuclear chemistry. (278 references). (M.C.G.)

**14030** PROCESSING OF HIGHLY IRRADIATED Al–Pu ALLOY. Berger, R.; Koehly, G.; Musikas, C.; Pottier, R.; Sontag, R. (CEN, Fontenay-aux-Roses, France). Nucl. Appl. Technol.; 8: 371-9(Apr 1970).

Four slugs containing a sum total of 20.950 g of plutonium as Al–Pu 10 % alloy were irradiated in the EL.3 reactor to an integrated flux of $5 \times 10^{21}$ n.cm$^{-2}$. After 2.5 years of cooling the processing was carried out in the hot cell "Petrus." It consisted of an alkaline and/or nitric dissolution of the "napkin-rings;" a plutonium separation by two extraction cycles with trilaurylamine (5 % v), each consisting of a plutonium extraction from a nitric medium and stripping by a solution containing sulfuric and nitric acids; a transplutonium element separation by two HDEHP (8 % v) extraction cycles, each consisting of an actinide-lanthanide extraction from an aluminium and lithium nitrates solution and a selective stripping of the transplutonium elements by a lithium nitrate solution containing diethylenetriaminopentaacetic ions (DTPA); and an americium/curium separation by anion exchange resin using a nitric solution containing a complexing agent as eluent. From these runs 2.6 g of plutonium, 150 mg of americium, and 15 mg of curium were recovered. The overall yields of plutonium and transplutonium elements were >97 and 98 % respectively and the β–γ decontamination factors $>10^5$. In general these results show clearly the effectiveness of solvent extraction in actinide reprocessing. (auth)

**14031** ON THE PURIFICATION OF RADIOACTIVE WASTE WATERS BY CONTACT PRECIPITATION. PART 4. THE INFLUENCE OF COMPLEXING AGENTS, DETERGENTS, AND SURFACE-ACTIVE AGENTS. Sachse, G.; Schlenkrich, H. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Kernenergie; 12: 363-7(Nov 1969). (In German).

Studies were made on the effects of waste water impurities, such as complexing agents and detergents, on the separation of $^{141}Ce$ and $^{89}Sr$ from waste water by the contact precipitation method using $CaCO_3$. It was found that oxalic acid, citric acid, and tartaric acid do not disturb coprecipitation through the process up to concentrations of 100 to 150 mg/l. Strong complexing agents, such as phosphates and EDTA may completely inhibit contact precipitation depending on concentration. In the case of detergents and surface-active agents no disadvantageous influences were found for concentrations up to 75 to 100 mg/l. (P.C.H.)

**14032** RAPID RADIOCHEMICAL SEPARATION OF SELENIUM: HALF-LIFE OF $^{83}Se$. Tomlinson, L.; Hurdus, M. H. (Atomic Energy Research Establishment, Harwell, Eng.). Radiochim. Acta; 12: 182-6(Dec 1969).

A rapid radiochemical method of separating selenium from fission products is described. The method is based on exchange between $H_2Se$ gas and aqueous selenite solutions and gives a chemical yield of 65% in 10 seconds with no contamination. The half-life of $^{83}Se$, separated from fission products by this method, is found to be 22.4 ± 0.2 min. (auth)

**14033** DEMINERALIZATION BY ION EXCHANGE IN WATER TREATMENT AND CHEMICAL PROCESSING OF OTHER LIQUIDS. Applebaum, Samuel B. New York; Academic Press Inc. (1968). 400p. $17.50.

Topics covered include: a brief history of ion exchange and the industrial needs that led to demineralization; a survey of impurities in water, their harmful effects in industry, and methods of removing them; removal of the major ionic dissolved impurities in water; removal of nonionic suspended and colloidal impurities; removal of gaseous impurities; the demineralization process and systems; the major American ion exchange materials; demineralizer equipment designs; demineralizer technical design calculations and typical examples, condensate purification for high-pressure utility and industrial boilers; demineralizing water treatment in nuclear power plants; comparison of evaporators and demineralizers and new demineralizer processes for desalination; continuous ion exchange; and chemical processing by ion exchange. A separate abstract was prepared for one chapter. (M.C.G.)

*For an abstract of one chapter see: 14034.*

**14034** DEMINERALIZING WATER TREATMENT IN NUCLEAR (ATOMIC) POWER PLANTS. pp 297-318 of Demineralization by Ion Exchange in Water Treatment and Chemical Processing of Other Liquids. /Applebaum, Samuel B. New York; Academic Press Inc. (1968).

Demineralizers are used in nuclear power stations for treating the coolant water so as to remove the long-lived impurities and thus reduce the buildup of radioactive deposits in the circulating system. Water-treatment plants for both pressurized-water and boiling-water systems are described. (17 references). (M.C.G.)

**14035** THE SEPARATION OF CERTAIN RADIOISOTOPES FROM A FISSION PRODUCTS SOLUTION. III. THE SEPARATION OF $^{95}Zr$ AND $^{95}Nb$. Deptula, Czeslaw; Moszynska, Krystyna; Buczek, Maria (Swierk Inst. for Nuclear Research, Poland). Nukleonika; 14: 635-45(1969). (In Polish).

$^{95}Zr$ and $^{95}Nb$ separation from a fission product solution by sorption on silica gel, as well as further separation of these nuclides by extraction using bis(2-ethylhexyl)phosphate is described. (auth)

**14036** EQUILIBRIA IN SOLUTIONS AND ANION EXCHANGE OF URANIUM(VI) COMPLEXES. II. SORPTION OF URANIUM (VI) ON AN ANION EXCHANGER FROM CARBONATE SOLUTIONS. Majchrzak, Kazimierz (Inst. for Nuclear Studies, Warsaw). Nukleonika; 14: 647-58(1969). (In Polish).

Anion exchange and the absorption spectra (400 to 500 mμ) of sorbed complexes were investigated. An explanation of the rela-

tion between the distribution coefficient of uranium and the carbonate concentration is given. It is assumed that the prevailing complex in the solution is $[H_hUO_2(CO_3)_3]^{4-h}$, and that it is sorbed on the anion exchanger. (auth)

**14037** SOLVENT EXTRACTION STUDIES BY THE AKUFVE METHOD. II. A NEW CENTRIFUGE FOR ABSOLUTE PHASE SEPARATION. Reinhardt, Hans; Rydberg, Jan (Chalmers Univ. of Tech., Goteborg). Acta Chem. Scand.; 23: 2773-80 (1969).

Three different commercial liquid-liquid flow centrifuges were tested with regard to absolute phase separation and general suitability for the requirements of the AKUFVE method. As a consequence a new type of centrifuge, the H-centrifuge was developed. A general description is given of its design and phase separation properties. (auth) (Denmark)

**14038** SOLVENT EXTRACTION STUDIES BY THE AKUFVE METHOD. III. EXPERIMENTAL TECHNIQUE FOR EQUILIBRIUM STUDIES USING RADIOACTIVE TRACERS. Andersson, C.; Andersson, S. O.; Liljenzin, J. O.; Reinhardt, H.; Rydberg, J. (Chalmers Univ. of Tech., Goteborg). Acta Chem. Scand.; 23: 2781-96(1969).

An experimental technique for the investigation of complex formation in liquid-liquid extraction systems by distribution measurements using the AKUFVE apparatus has been developed. Its main advantages are great speed and precision. An experimental system with radiometric detectors and a datalogging unit is described. The experimental procedure is discussed in detail with reference to experiments with the chemical system copper(II)–acetylacetone–benzene–1 M sodium perchlorate and experimental results are given. Future development of the measuring system and the technique is outlined. (auth) (Denmark)

**14039** PURIFICATION OF PROTACTINIUM OBTAINED BY SPALLATION. Borg, J.; Chevallier, P.; Touati, A.; Briand, J. P. Inorg. Nucl. Chem. Lett.; 6: 97-101(Jan 1970). (In French).

Fission products formed in 51-MeV proton irradiation of thorium were identified as Nb, Zr, Ru, Sb, I, Ce, and Ba a fortnight after irradiation, by γ spectrometry in an aqueous back-extract from TTA/benzene extracts of nitrate solutions of irradiated targets. Methods are described for removing these elements to obtain pure protactinium. (UK)

**14040** THE SORPTION OF $^{137}Cs$, $^{89}Sr$, $^{60}Co$, AND $^{106}Ru$ FROM NaCl SOLUTIONS ON SYNTHETIC ZEOLITE LINDE 4A. Gacinovic, O. M.; Radovanov, P. D.; Gal, I. J. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Isotopenpraxis; 5: 420-1(Nov 1969).

The distribution of the radioactive tracers $^{137}Cs$, $^{89}Sr$, $^{60}Co$, and $^{106}Ru$ between 4A zeolite and an aqueous solution of variable pH and salt concentration. At lower pH values, a decrease in molal distribution occurred. Simple ion-exchange equilibrium governed the distribution of cations above NaCl concentrations of $1 \times 10^{-2}$ M. (M.C.G.)

**14041** RAPID SEPARATION OF METALLIC IONS AND $^{140}Ba$–$^{140}La$ BY THIN-LAYER ELECTROPHORESIS. Mori, Itsuhiko; Tsunematsu, Norika (Kobe Women's Coll. of Pharmacy, Japan). Yakugaku Zasshi; 89: 1669-72(Dec 1969). (In Japanese).

Some 34 common metallic ions were separated rapidly and identified by thin-layer electrophoresis on one piece of thin-layer Chromatosheet (Eastman Kodak Co., silica gel). Fundamental experiments were carried out using citric acid as the electrolytic solution. The relationship between the migration distance and migration time as well as the electric potential gradient, the concentration of citric acid, and pH of the electrolytic solution were examined. The electrophoresis was carried out for 5 min with 300 V/6.5 cm, using 0.1M citric acid as the electrolytic solution. The samples were spotted at 1.5 cm from the chromatostrip end (anode side). Electrophoresis of $^{140}Ba$–$^{140}La$ was also carried out for 5, 7, and 10 min, and about 90% separation of $^{140}La$ was obtained by electrophoresis for 10 min. (NSA of Japan)

# EARTH SCIENCES

## Geology and Hydrology

*Refer also to abstracts 13809, 13810, 13988, 14329, 14443, and 16115.*

**14042** (BNWL–1051(Pt.1), pp 78–82) EVAPORATIVE COOLING OF HEATED IRRIGATION WATER BY SPRINKLER APPLICATIONS. Cline, J. F.; Wolf, M. A.; Hungate, F. P. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

By passing water through a standard irrigation sprinkler, heated water was cooled to temperatures satisfactory for plant growth. Reducing the droplet size was the most important factor affecting the rate of heat loss. Droplet temperatures approached but did not reach wet bulb temperatures. (auth)

**14043** (RLO–1750–54, pp 10–11) IN SITU PROBE MEASUREMENT OF $^{51}Cr$. Forster, William O.; Larsen, Lauren; Wagner, Jerry (Oregon State Univ., Corvallis. Dept. of Oceanography).

Two important advantages of in situ measurement of $^{51}Cr$ activities in estuarine water as compared with precipitation techniques are that the probe detects all forms of $^{51}Cr$ and that the results are immediately available. The results of in situ gamma detection of $^{51}Cr$ activities in the Columbia River Estuary and plume are plotted, and show that the maximum activities were at ebb tide, the maximum dilution of the Estuary water by the sea water occurred at flood tide, and that this diurnal change in activities due to seawater dilution is approximately equal to the yearly change in activities due to water discharge of the Columbia River. (L.C.L.)

**14044** (RLO–1750–54, pp 13–15) LARGE VOLUME PRECIPITATION. Forster, William O.; Larsen, Lauren (Oregon State Univ., Corvallis. Dept. of Oceanography).

Large volume (600 liter) precipitation techniques were used on a plume cruise to determine the changing activities of $^{51}Cr$, $^{46}Sc$, and $^{65}Zn$ in the Columbia River, Estuary, and in off-shore waters. Each activity was mathematically corrected to the activity it would be if dilution by seawater were the only cause of the lowered activities in brackish and high salinity water. The results of measurements for all three isotopes showed that there is a removal of the river radioisotopes on mixing with the incoming tide with a subsequent renewal of activities in high salinity water. The particulate elements showed almost full recovery while soluble $^{51}Cr$ showed only 59% recovery. (L.C.L.)

**14045** (RLO–1750–54, pp 16–18) SORPTION TECHNIQUES TO CHARACTERIZE THE FORM AND DEPTH OF COLUMBIA RIVER PLUME WATER. Forster, William O.; Larsen, Lauren; Wagner, Jerry; Perkins, Dick (Oregon State Univ., Corvallis. Dept. of Oceanography).

A new reduction-sorption method was used to measure the depth and distribution of $^{51}Cr$ carried to the ocean by the Columbia River. Pumping seawater at 38 liters per minute through four parallel 30 cm diameter fiber glass filters removed the particulate fraction in the water. This water then passed through a thick adsorption bed of 28 cm diameter by 0.7 cm thick which consists of $Al_2O_3$ impregnated with $SnCl_2$. This provided quantitative retention of the dissolved $^{51}Cr$ (+6). These filter sorption beds were changed every sample, and, following their return to the laboratory, were counted directly in a 9 in. NaI(Tl) well crystal. The sensitivity is 0.01 pCi/l for $^{51}Cr$ which is $10^6$ dilution to the values in the up-river reach of the Columbia. One hour pumping easily collected the $^{51}Cr$ from over 2000 liters of seawater, resulting in a convenient 500 ml sample ready to be counted directly. Estimates in the lab were made that up to 6000 liters of seawater could conveniently be passed through the beds before saturation of $^{51}Cr$. All samples were run as duplicates. The range in relative standard deviations for the soluble fraction is from 1.5% to 22%. The latter value includes a variable depth sample due to the swift tidal action in the Estuary. The particulate fraction also had a wide range of precision from less than 1% relative standard deviation to over 200%. The Estuary sample size averaged approximately 200 liters of water before plugging the filters while the cleaner seawater did not reduce the flow rates with over 2000 liters through the beds. The results of $^{51}Cr$ measurements at various Estuary stations and in adjacent plume water were tabulated. The mean soluble river $^{51}Cr$ (+6) activity was 252 pCi/l with the particulate fraction equal to 30 pCi/l, making a total $^{51}Cr$ equivalent to 282 pCi/l with 10% being particulate in this high salinity water. (L.C.L.)

**14046** (RLO–1750–54, pp 30–2) COLUMBIA RIVER FLOW TIMES DURING THE 1966 HANFORD REACTOR SHUTDOWN. Forster, William O.; Hanson, Peter J. (Oregon State Univ., Corvallis. Dept. of Oceanography).

In 1966 during a 49-day suspension of Hanford nuclear operations, the $^{51}Cr$ and $^{65}Zn$ contents in water samples taken from the Columbia River were measured and used to obtain river flow data. The results are presented and factors which explain the range in calculated river flow times are discussed. (L.C.L.)

**14047** (RLO–1750–54, pp 43–4) $^{124}Sb$ IN THE LOWER COLUMBIA RIVER. Pope, Stephen V. W.; Renfro, W. C.; Forster, W. O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

A method for calculating Columbia River flow times from measured data on the amounts of soluble $^{51}Cr$ and $^{124}Sb$ at two different river stations is presented, and its limitations discussed. (L.C.L.)

**14048** (RLO–1750–54, pp 45–6) EFFECTS OF PAPER MILL WASTES ON PARTICULATE ACTIVITY OF $^{65}Zn$. Pope, Stephen V. W.; Forster, W. O.; Renfro, W. C. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Evidence that sulfite waste liquors from a paper mill may decrease the particulate activity of $^{65}Zn$ in the Columbia River is presented. (L.C.L.)

**14049** (RLO–1750–54, pp 47–50) THE EFFECTS OF KRAFT MILL WASTES AND DOMESTIC POLLUTANTS ON DISSOLVED METALLIC ELEMENTS IN AQUATIC ENVIRONMENTS. Hennebry, H. M.; Forster, William O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

The effects of Kraft mill waste effluents (sulfite liquors) and city sewage discharges on trace amounts of sodium and magnesium in the Columbia River were studied. Neutron activation analysis was used to study river diffusion, cation exchange capacity of filterable solids from the effluents, and trace elemental abundance. The chemical features of each effluent were determined. The effect of various wastes on dissolved elements in aquatic environments can help clarify potential routings and reservoirs for radioisotopes which may be introduced into similar environments. (L.C.L.)

**14050** (RLO–1750–54, pp 51–4) $^{51}Cr/^{65}Zn$ RATIOS IN COLUMBIA RIVER ESTUARINE WATER DURING TIDAL CHANGES. Forster, William O.; Hanson, Peter J. (Oregon State Univ., Corvallis. Dept. of Oceanography).

The $^{51}Cr/^{65}Zn$ ratios in Columbia River Estuary water during tidal changes and the range of activities of particulate and soluble $^{51}Cr$ and $^{65}Zn$ at high and low tide were measured. The following features were noted: the ratios are approximately 15 times greater for the soluble fractions than for the particulate fractions; the ratios at high tide were in general, greater than at low tide (This is especially so, in the case of the particulate fractions, where the high tide ratios averaged 80% more than the low tide ratios); although the low tide lacked salinity changes, the soluble ratios had pronounced peaks and valleys; the obvious soluble maxima occurs at depth of high tide; the divergence of the high and low tide values for the particulate fraction; and the relative standard deviation of all four relationships is approximately the same (13%) even though there are no salinity effects at low tide. (L.C.L.)

**14051** (RLO–1750–54, pp 55–7) PARTICULATE $^{65}Zn$ AND $^{51}Cr$ IN COLUMBIA RIVER ESTUARY. Forster, William O.; Hanson, Peter J. (Oregon State Univ., Corvallis. Dept. of Oceanography).

The effects of tides on the percentage of particulate $^{51}Cr$ and $^{65}Zn$ in the Columbia River Estuary were investigated. No correlation between salinity and percentage of these radioisotopes was established. It is concluded that the scouring action of tides which causes surface sediments to be loosened and resuspended in solution could be the main factor in increasing the percentages of particulate $^{51}Cr$ and $^{65}Zn$. (L.C.L.)

**14052** (RLO–1750–54, pp 58–60) YEARLY VARIATION OF SPECIFIC ACTIVITIES OF $^{65}Zn$ IN THE COLUMBIA RIVER ESTUARY. Forster, William O.; Wagner, Jerry (Oregon State Univ., Corvallis. Dept. of Oceanography).

Between June 1967 and May 1969, the concentrations of stable zinc and $^{65}Zn$ and the specific activities of $^{65}Zn$ were measured at three areas in the Columbia River Estuary. The results are presented. (L.C.L.)

**14053** (RLO–1750–54, pp 92–5) DISTRIBUTION OF $^{65}Zn$ AND $^{60}Co$ IN FRACTIONATED SEDIMENTS OF THE COLUMBIA RIVER ESTUARY. Delaplane, W. H.; Forster, W. O.; Renfro, W. C. (Oregon State Univ., Corvallis. Dept. of Oceanography).

The usefulness of $^{65}Zn/^{60}Co$ ratios as tracers of sediment movement from the Columbia River is based on the assumption that the ratio of $^{65}Zn/^{60}Co$ is a constant as the particles enter the marine environment. Experiments were performed to test the validity of this assumption. Columbia River sediments were fractionated into sand, silt, and clay. The $^{60}Co$ and $^{65}Zn$ content in the fractioned sediments were measured. The possible correlation between variability levels of radioactivity in each fraction with the presence of oxidizable organic material was investigated. Preliminary tests showed that the $^{65}Zn/^{60}Co$ ratios in bulk sediments throughout the estuary varied from 2.48 to 43.4 with a mean of 11.5. The current experiments showed that the highest average values of organic matter (5.66%), $^{65}Zn$ activity (77.85 pCi/g), and $^{60}Co$ activity (5.35 pCi/g) occur in the clay fraction as one might expect from surface area considerations. However, clay has the lowest average $^{65}Zn/^{60}Co$ ratio. This may be attributed to the fact that variation in $^{65}Zn/^{60}Co$ ratios correlate to variation in $^{60}Co$ activity. For the several clay fractions $^{65}Zn$ and $^{60}Co$ values are given and plotted as a function of the $^{65}Zn/^{60}Co$ ratio. The increase in ratio is shown to be the result of changing $^{65}Zn$ values but corresponds to a decrease in $^{60}Co$ values. (L.C.L.)

**14054** (USGS–474-36(Rev.1)) NEAR-SURFACE SINK STRUCTURE, NEVADA TEST SITE. Houser, F. N. (Geological Survey, Denver, Colo.). Jan 1970. Contract AT(29-2)-474. 30p. (NTS–217(Rev.1)). Dep. CFSTI.

Little has been observed of the subsurface structure of sinks, and selected sinks should be explored by relatively economical means of trenching and shallow core drilling. These types of exploration could provide much needed information about the size and shape of the near-surface collapsed zone for solving such problems as the calculation of bulking factors and the spacing and containment-evaluation of future sites. The basic structure in the outer part of one funnel-type sink—at U3co—is characterized by an inward-dipping landslide block, a shear surface of failure beneath the landslide block (inward dip ≈45°), and subsidiary slump blocks and tension fractures in and near the extreme outer part of the sink. Analogies of these structures to normal landslide structures suggest that many of the methods and interpretations used in landslide analysis can provide inferences as to the size and structure of deeper subsurface collapse zones. On this basis, it is suggested that the shear surface extends inward to where it would intersect a cylindrical-shaped collapse chimney that formed approximately vertically above the explosion cavity. (auth)

**14055** EXPERIMENTAL CONDITIONS OF FRENCH UNDERGROUND NUCLEAR EXPLOSIONS IN THE SAHARA, FROM 1961 TO 1966. Duclaux, Francoise; Michaud, Lucien (CEA, Bruyeres-le-Chatel, France). Compt. Rend., Ser. B; 270: 189-92(12 Jan 1970). (In French).

Thirteen underground nuclear explosions took place in the Taourirt Tan Afella mountains (Hoggar). Geological and tectonic characteristics of the batholith are given. Experimental conditions of the explosions are described and mechanical, geological, and geophysical results are briefly enumerated. (auth) (France)

**14056** RARER-ELEMENT DISTRIBUTION IN METAMORPHIC CONGLOMERATES OF THE URALS. Khvostova, V. A. (Inst. of Rarer-Element Mineralogy, Geochemistry, and Chemical Crystallography, Moscow). Geochem. Int. (Engl. Transl.); 6: 288-94(1969). Translated from Geokhimiya; No. 3, 328-34(1969).

Enrichment of Ta, Nb, RE, Zr, Th, and U was observed in highly altered conglomerates lying near granites and formed by erosion of granites containing rarer metal mineralization. These elements formed their own minerals as well as appearing as isomorphous components of other minerals. These elements did not accumulate in less altered Precambrian conglomerates or in parts of the conglomerates remote from the contact with granites. (auth)

**14057** ENGINEERING GEOLOGY NEAR SITE OF ATOMIC POWER STATION AT TSURUGA. 2. Nasu, Nobuji (Waseda Univ., Tokyo). Waseda Daigaku Rikogaku Kenkyusho Hokoku; No. 45, 1-8(Sep 1969).

The ground in the Tsuruga area, the site for a Japan Atomic Power Company power station, is composed of granite with fissures and fracture zones. Engineering geology studies of the area are described. Trenches were excavated where the reactor plant is to be erected, and a tunnel was cut to investigate the elasticity of rocks. Seismic prospecting was carried out along the length of the tunnel. Calculations were made of the elastic constants of the rocks from seismic-wave velocity data. Static loading tests were made at six points in the tunnel. The superficial soil layer is described with emphasis on the thickness of the layer. Elastic constants of the superficial layer were calculated and were in agreement with those found by static loading tests. The deformation of the soil layer and basement rock was examined. (NSA of Japan)

**14058** LEAD AND STRONTIUM ISOTOPES IN VOLCANIC ROCKS FROM NORTHERN HONSHU, JAPAN. Hedge, Carl E.; Knight, Roy J. (Geological Survey, Denver). Geochem. J. (Nagoya); 3: No. 1, 15-24(Aug 1969).

Isotopic compositions of lead and strontium and concentrations of lead, uranium, thorium, rubidium, and strontium were measured in a suite of volcanic rocks, ranging from basalt to rhyodacite in composition, and in granite and gabbro xenoliths for a traverse across northern Honshu. The observed $^{238}U/^{204}Pb$ ($\mu$) ratio ranges from 2.4 in tholeiitic basalt at the east end of the traverse to 11.6 in alkalic basalt from the west end. The isotopic composition is slightly less radiogenic to the west. The $^{87}Sr/^{86}Sr$ ratios of most of the samples fall within the range observed in oceanic basalts, but the granite xenolith and the rhyodacite are slightly more radiogenic. (NSA of Japan)

**14059** ISOTOPIC COMPOSITION OF LEAD IN VOLCANIC ROCKS FROM CENTRAL HONSHU WITH REGARD TO BASALT GENESIS. Tatsumoto, Mitsunobu; Knight, Roy J. (Geological Survey, Denver). Geochem. J. (Nagoya); 3: No. 1, 53-86(Aug 1969).

The isotopic composition of lead and concentrations of lead, uranium, and thorium were determined in tholeiitic and high-alumina basalts, and their calc-alkali rock series, from central Japan. The isotopic composition of lead of high-alumina basalts is similar to that of tholeiites from adjacent areas, whereas their silicic differentiates (calc-alkali rock series) are rich in $^{207}Pb$ and $^{208}Pb$. This is interpreted as a result of crustal contamination. The isotopic composition of lead in the primary basalts gradually decreases in radiogenic character from the Pacific Ocean side to the Japan Sea side, whereas the observed $^{238}U/^{204}Pb$ and $^{232}Th/^{238}U$ ratios in the basalts increase in the same direction. This inverse correlation can be interpreted as resulting from differentiation of the upper mantle about 3.6 b.y. ago, with tholeiite (Pacific side) generated from a shallower zone than the alkali basalt (Japan Sea side). The magma generation is associated with a process which extracts Pb preferentially to U and Th at shallower depth and U and Th preferentially to Pb at deeper depth in the past (multi-differentiation for the source region) or at the magma generation stage. An alternative interpretation of this inverse correlation is that the ocean floor is being thrust under the Japanese Island arcs and the isotopic difference is produced by the degree of mixing of mantle material under the arcs with thrust material. (NSA of Japan)

**14060** ALPHA-AUTORADIOGRAPHY AND MORPHOLOGY OF ACCESSORY ZIRCON SUITES. Ragland, Paul C. (Univ. of North Carolina, Chapel Hill). Southeast. Geol.; 11: 1-19(Nov 1969).

The site of the $\alpha$ emitters U and Th in the zircon lattice was studied, and $\alpha$-autoradiographic and morphologic data were correlated. Parameters that best characterized a zircon suite and enabled it to be distinguished from other suites were found to be elongation ratio, rounding ratio, and dispersion of volume histograms. Zircons from 5 bentonites were apparently from a homogenous population with respect to site, elongation, and $\alpha$-activity, indicating that they crystallized under similar physiochemical conditions. Apparently $U^{4+}$ and $Th^{4+}$ occupy regular lattice positions in zircon. Relatively high Th/U ratios in pegmatitic zircons compared with granitic zircons were explained by preferential entry of $U^{4+}$ into the zircon lattice during magmatic fractionation; and oxidation of $U^{4+}$ to $(UO_2)^{2+}$ and its subsequent leaching during the pegmatitic stage of magmatism. A few grains in some of the suites that were observed to be considerably more radioactive than normal zircons were generally monazite and rarely malacon or metamict zircons. (BBB)

**14061** RADIONUCLIDE RETENTION FROM DILUTE SOLUTIONS BY PANAMANIAN SOIL CLAYS. Goldsmith, William Alee. Gainesville, Fla.; Univ. of Florida (1968). 168p. Thesis.

The retention of the radionuclides $^{45}Ca$, $^{89}Sr$, $^{137}Cs$, and $^{86}Rb$ was determined for six selected Panamanian soil clay fractions. The clays were separated from soils representing the major types present in the sea level canal feasibility study area. The sorption of the radionuclides was determined using the slurry test. The slurries were run with the radionuclides paired into two stock solutions: $^{137}Cs$ with $^{86}Rb$ and $^{45}Ca$ with $^{89}Sr$. Gamma emitters were counted by gamma spectroscopy, beta emitters by liquid scintillation counting. Each stock solution was prepared from commercially prepared radionuclide chloride solutions diluted to 50 $\mu$Ci/l with distilled water. The results of the slurry test followed the linear function $C/U = b(K_2/K_1) + bC$ where U is the percent uptake at clay concentration C; b is the inverse of the ultimate uptake, the percentage of radiocations which would ultimately be sorbed from solution by an infinite mass of clay; $(K_2/K_1)$

is the half dosage, the clay concentration required to sorb one-half of the ultimately sorbable cations, expressing the efficiency or selectivity of the clay for sorbing the radionuclide. This equation was derived on the basis that the mass of clay is the most important consideration in the determination of radionuclide uptake by the slurry test. The derivation was analogous to that of the Langmuir adsorption isotherm. The results obtained for the six Panamanian soil clays suggested that the soil colloid fraction in the Panamanian study area represents a limitless reservoir capable of sorbing soluble fallout radiocations that would be produced in nuclear excavating techniques. The selectivity for each Panamanian soil clay under the conditions for which they were tested, expressed by the half dosage, generally followed the sequence: $^{45}Ca = {}^{89}Sr > {}^{137}Cs > {}^{86}Rb$. Neither the ultimate uptake nor the half dosage could be correlated with either the cation exchange capacity or surface area parameters of the six clays tested. The results of slurry tests performed by seven other investigators also were well described by the equation derived in this study. All results indicated that the half dosage requirement of a radionuclide for any clay depended on the type of clay mineral present, the ionic size and charge of the radionuclide, the chemistry of the substrate solution, and the time of contact for nonexpanding lattice, clay minerals. The ultimate uptake value was apparently influenced very slightly by the type of clay mineral involved and by the chemical nature of the substrate solution. (Diss. Abstr. Int., B)

**14062** URANIUM ISOTOPES IN SEA-FLOOR PHOSPHORITES. Kolodny, Yehoshua; Kaplan, I. R. (Univ. of California, Los Angeles). Geochim. Cosmochim. Acta; 34: 3-24(Jan 1970).

Analyses of uranium concentration and $^{234}U/^{238}U$ activity ratios were performed on 40 samples of marine phosphorites, almost all of them dredged from the present sea floor. In each sample, the concentration and isotopic composition of total uranium and U(IV) were analyzed. Uranium concentrations in the analyzed nodules varied between 6 and 524 ppM, tetravalent uranium constituting 38 to 84 per cent of the total. Whereas the mean activity ratio for total uranium was 0.97, the ratio in the U(IV) uranium was 0.71 and the calculated activity ratio for U(IV) uranium was 1.57. The interpretation of these results has two consequences: All the analyzed nodules are old (probably older than $8 \times 10^5$ yr), and are at the present being eroded rather than deposited; hence, the deposition of phosphorite in the present day ocean is rather doubtful. The difference in isotopic ratios between the two oxidation states of uranium generally confirms previously proposed mechanisms of uranium isotope fractionation. Differential oxidation of $^{234}U$ is largely responsible for the measured $^{234}U/^{238}U$ disequilibrium ratios. A model for evolution of uranium isotope activity ratios in different oxidation states is presented. (auth) (UK)

**14063** DIFFUSION FROM A GASEOUS SOURCE IN A POROUS MEDIUM: A FIELD AND THEORETICAL COMPARISON. Robertson, John B. U. S., Geol. Surv., Prof. Pap.; No. 650-D, 265-73 (1969).

Small volumes of air containing a radioactive krypton-85 tracer were injected into fine-grained sediments at the National Reactor Testing Station, Idaho. Dissipation of the $^{85}Kr$ gas away from the injection points was observed by recording the gamma radioactivity in the holes. A mathematical model was adapted from a heat-flow analogy to estimate the amount of molecular diffusion occurring in the system. The observed field data match the theoretical diffusion curves closely, indicating that most of the observed outflow was due to diffusion. (auth)

**14064** THE IMPLICATIONS OF URANIUM ISOTOPE DISTRIBUTION ASSOCIATED WITH THE FLORIDAN AQUIFER OF NORTH FLORIDA. Rydell, Harold Stanford. Gainesville, Fla.; Florida State Univ. (1969). 127p.

Thesis.

Naturally occurring uranium isotopes in waters of the Floridan aquifer of North Florida were found to be quantitatively useful in evaluating mixing proportions of waters from different sources. The aquifer waters of the Woodville Karst Plain located in the southern part of the study area have anomalously low U-234/U-238 activity ratios which are difficult to reconcile with previously offered mechanisms of uranium isotope fractionation. Reexamination of the natural fractionation of uranium isotopes leads to a valence associated isotopic distribution model. The model considers the various decay and oxidation-reduction processes that affect the distribution of U-238 and U-234 within a system. It further indicates potential sources of uranium with activity ratios above and below unity as well as equilibrium activity ratios. The proposed valence associated isotopic distribution model is supported by valence separated isotopic uranium analyses of Tertiary limestone. Quantitative relationships evaluating certain types of uranium leaching are derived from the model. A second model describing activity ratio fluctuation in certain aquifer waters in response to Pleistocene sea level changes is proposed. Valence associated uranium isotope distributions show promise for making further significant contributions in uranium geochemistry. (Diss. Abstr.)

**14065** U-Th-Pb AGES OF ZIRCON FROM THE RYOKE METAMORPHIC TERRAIN, KINKI DISTRICT. Ishizaka, Kyoichi (Kyoto Univ.). Ganseki Kobutsu Kosho Gakkaishi; 62: 191-7 (Sep 1969). (In Japanese).

U-Pb-Th ages of three zircons of granitic and metamorphic rocks from Ryoke metamorphic zone in the Kinki district were determined. Two zircons from granitic rocks yielded $^{206}Pb/^{238}U$ age of approximately 90 Myr which is consistent with the results obtained by Rb-Sr method on mica samples of this metamorphic terrain, suggesting the intrusion of the granitic rocks and metamorphism may have taken place about 90 Myr ago. Detrital zircon of metamorphosed Paleozoic sedimentary rock yielded quite discordant U-Pb age, $^{207}Pb/^{206}Pb$ age being as old as 1792 Myr. This result may indicate the presence of acidic crystalline rocks of Precambrian age near the so-called Permo-Carboniferous Paleozoic rock region, probably in the Japan Sea. (auth)

**14066** MEASUREMENT OF ATMOSPHERIC PRESSURE AND SUBSURFACE-GAS PRESSURE IN THE UNSATURATED ZONE OF THE BANDELIER TUFF, LOS ALAMOS, NEW MEXICO. Kunkler, J. L. (Los Alamos Scientific Lab., N. Mex.). U. S., Geol. Surv., Prof. Pap.; No. 650-D, 283-7(1969).

Pressure transducers, power supplies, and potentiometric recorders were assembled into portable pressure-monitoring systems which measured pressures in the field with an accuracy of about 0.3%. The performance of some of the components was affected by fluctuations in field temperatures; hence these components were operated in a constant-temperature chamber. The data show that the subsurface-gas pressures responded to changes in the atmospheric pressure to depths of 35 meters in the Bandelier Tuff; the response was completely attenuated at some depth between 35 and 89 m. (auth)

**14067** ATTI DEL XV CONVEGNO ANNUALE, ROMA, 16-17 GIUGNO 1966. ASSOCIAZIONE GEOFISICA ITALIANA. (Proceedings of the 15th Meeting, Rome, June 16-17, 1966. Italian Geophysics Society). Ass. Geofis. Ital., Atti Conv. Annu.; 15: 1-566(Jun 1966). (In Italian and English). (CONF-660672).

Separate abstracts are prepared for 8 of the 32 papers presented. (C.E.S.)

*For abstracts of individual papers see: 14068, 14087-14091, 14283, and 14300.*

**14068** ON THE RADIOACTIVITY OF LAVA FROM THE VILLARRICA VOLCANO. Casertano, Lorenzo. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 189-203(Jun 1966). (In Italian).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

The gamma ray spectra of samples from seven lava flows of Villarrica, were examined. Considering the variations of the $^{238}U$, $^{232}Th$, and $^{40}K$ contents and of their ratios with the time, an increase of the $^{238}U$, a steadiness of the $^{40}K$ content and an irregular variation of the $^{232}Th$ content was pointed out. The correlation between the $^{238}U$ and $^{232}Th$ was linear, while that between $^{238}U$ and $^{40}K$ and between $^{232}Th$ and $^{40}K$ was exponential. The variation of the radioisotopic content with the chemism of the lavas did not always follow the same trend; there was a reversal, i.e., the trends presented a maximum or minimum value according to the parameter chosen for representing the chemism. (auth)

## Meteorology

*Refer also to abstracts 14119 and 14283.*

**14069** (BNWL-1051(Pt.1)) PACIFIC NORTHWEST LABORATORY ANNUAL REPORT FOR 1968 TO THE USAEC DIVISION OF BIOLOGY AND MEDICINE. VOLUME II. PHYSICAL SCIENCES. PART 1. ATMOSPHERIC SCIENCES. Simpson, C. L.; (and others) (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Nov 1969. Contract AT(45-1)-1830. 92p. Dep. CFSTI.

Research progress in atmospheric science studies is reported in thirteen sections. A separate abstract was prepared for each. (L.C.L.)

*For abstracts of individual sections see: 14042, 14070-14079, 14119, and 14120.*

**14070** (BNWL-1051(Pt.1), pp 1-4) RESULTS OF FIELD INVESTIGATIONS OF THE EFFECT OF SOURCE HEIGHT AND STABILITY ON ATMOSPHERIC EXPOSURE. Nickola, P. W. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

A series of field tracer releases was conducted during stable

atmospheric conditions. The tracer release height was 85 ft. Tracer sampling occurred at an elevation of 5 ft above ground level at distances between 0.4 and 12.8 km. Results from these field tests are presented in the form of normalized tracer exposures versus travel time for several thermal stratifications of the atmosphere. These results are compared with similar results from releases at elevations of 23 and 185 ft. (auth)

**14071** (BNWL-1051(Pt.1), pp 5-13) PEAK-TO-MEAN CONCENTRATION RATIOS AS A FUNCTION OF CROSSWIND POSITION WITHIN THE MEAN PLUME AND THE RATIO OF THE DURATION OF THE MEAN TO DURATION OF THE PEAK. Ramsdell, J. V. Jr.; Hinds, W. T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Diffusion data obtained from four short duration continuous releases of $^{85}Kr$ are analyzed to examine concentration fluctuations at various positions on a fixed sampling grid. Following a discussion of the effects of atmospheric stability and distance from the source on concentration fluctuations, a detailed study is made of the magnitude of the fluctuations as a function of: crosswind position within the mean plume, and the ratio of the duration of the mean concentration to that of the fluctuation (time ratio). In particular, peak-to-mean concentrations are found to be an exponential function of the normalized crosswind position within the mean plume, although the relationship differs in form from that derived by Gifford in 1960. A single power law is found to be inadequate to fully describe the relationship between peak-to-mean ratios and the time ratio; however, at time ratios greater than 4 the experimental relationship follows an approximate power law. The data suggest that peak-to-mean ratios estimated for positions near the mean centerline by Gifford (1960) are significant underestimates. A working model for estimating peak-to-mean concentration ratios which combines the exponential and power law relationships is given. (auth)

**14072** (BNWL-1051(Pt.1), pp 14-17) ATMOSPHERIC TURBULENCE STUDIES. Elderkin, C. E.; Horst, T. W.; Draper, J. C. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Seventeen turbulence experiments were performed with the Hanford Wind Component Meter, measuring temperature and the three components of the wind at various heights up to 24.4 m during widely varying stability conditions. Simultaneous measurements were made of the mean profiles of temperature and wind speed and direction. During four of these experiments, the WCM was at 3 m and a sonic anemometer–thermometer was at 60 m, which gave data that are useful for further determination of the height dependence of turbulence characteristics and for determination of the vertical divergence of meteorological fluxes. A third sonic instrument has been added at an intermediate level for experiments which will allow inclusion of the divergence of the vertical flux of turbulent kinetic energy in the turbulent energy budget. Reduction of the test data has only recently begun. (auth)

**14073** (BNWL-1051(Pt.1), pp 18-25) EXPERIMENTAL STUDIES IN PRECIPITATION SCAVENGING. Wolf, M. A.; Dana, M. T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Silver iodide test data were compiled and showed a well-defined relationship between washout coefficients and precipitation rates in in rain. Test data from snow scavenging present more scatter but reveal a relationship which does not differ markedly from that in rain. Further analysis of washout coefficients derived in previous tests of dry-generated fluorescent dye showed good agreement with theoretical values based on experimental collection efficiencies. The development of a capability for particle size control was undertaken to extend the precipitation scavenging studies of particle size effects. Measurements of raindrop electric charge data collected at a site on the Olympic Peninsula of Washington indicated predominantly positive charges. Calculated precipitation electric currents best describe the raindrop electrification, although the raindrop charge spectrometer transducer apparently does not effectively sample the entire raindrop spectrum. (auth)

**14074** (BNWL-1051(Pt.1), pp 26-9) PRECIPITATION CHARACTERISTICS: SHIPBOARD MEASUREMENTS IN THE CARIBBEAN SEA. Dana, M. T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Measurements of raindrop electric charge and size and rainfall intensity were made aboard USCGSS Discoverer in the southeast Caribbean Sea. The shipboard electric charge detection unit proved adequate for the highly charged convective rainfall experienced. It was found that the raindrop collections have relatively low net charge averages, while individual raindrops were highly charged. Raindrop size distributions were found to be similar to Pacific Northwest rain, but with greater number of large raindrops. Three methods of measuring precipitation intensity produced comparable results, though all were potentially limited in accuracy. (auth)

**14075** (BNWL-1051(Pt.1), pp 30-4) THE TRANSFER OF AIRBORNE RADIONUCLIDES ACROSS THE SEA SURFACE AT 13°N, 58°W. Young, J. A. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Air filter samples were collected twice a day at 7, 25, and 76 ft above mean sea surface aboard the USCGSS Discoverer stationed east of Barbados, British West Indies, at 13° N during August, 1968. Beryllium-7 (53 days), $^{95}Zr$–Nb (65 days), $^{103}Ru$ (40 days), $^{106}Ru$ (1.0 yr), $^{137}Cs$ (30 yr), and $^{140}Ba$ (12.8 days), concentrations were determined in these samples. The radionuclide concentrations increased significantly from the 7- to the 25-foot sample, but averaged the same in the 25- and 76-foot samples. The concentration increase was greater for samples collected during the day than for those collected during the night. Rain samples and seawater samples down to 210 m were also collected aboard the Discoverer. (auth)

**14076** (BNWL-1051(Pt.1), pp 35-45) DIABATIC TRAJECTORIES AND A TRAJECTORY CASE STUDY OF THE EFFLUENT FROM PHOEBUS 1B EP-IV, FEBRUARY 23, 1967. Davis, W. E.; Scott, B. C. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Procedures for estimating diabatic effects and techniques for the inclusion of these effects in a trajectory calculation have been presented. A trajectory case study of the effluent from Phoebus 1B EP-IV, February 23, 1967, has been utilized to demonstrate the application of some of the procedures for estimating and including the diabatic effects into a trajectory calculation. (auth)

**14077** (BNWL-1051(Pt.1), pp 52-8) PARTICLE DEPOSITION FROM TURBULENT FLOW. Sehmel, G. A.; Schwendiman, L. C. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

A theoretical model was investigated to effectively describe turbulent deposition of particles onto surfaces. Particle transport to the deposition surface is described by particle eddy diffusivities. Two innovations from published deposition models are incorporated into the new model. The first of these is the discarding of the concept that the particle is finally brought to the surface by "free-flight" due to its inertia. The second is that particle eddy diffusivities are not the same as eddy diffusivities for air momentum as is generally assumed. In this study, the particle eddy diffusivities are back calculated from the deposition data. From these calculations, it is concluded that particle turbulent diffusivities are greater than those for air momentum transfer in turbulent flow. The general range of these particle eddy diffusivities has been determined. Continuing study is directed at determining the functional relationship between particle diffusivities and particle properties, air properties, and the distance from the deposition surface. Since the final diffusivity relationship has not been established, the model cannot yet be used to predict deposition. Consequently, all available data on turbulent deposition velocities of particles to the walls of vertical conduits were correlated with an empirical dimensionless equation containing the important variables. (auth)

**14078** (BNWL-1051(Pt.1), pp 59-61) BROWNIAN DIFFUSION IN A NONUNIFORM GAS. Slinn, W. G. N. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

The motion of a small Brownian particle in air that is in thermal and translational nonequilibrium has been analyzed. A new force is described which is similar to that used to explain the thermophoresis effect but which depends on the viscous stress in the gas. The solution to the new Fokker–Planck equation in velocity space has been found. In the generalized convective-diffusion equation, the diffusion coefficient appears as a second order tensor and exhibits the influence of the viscous stress tensor on diffusion. The results are limited to the case when the particle's Knudsen number is large compared to unity. (auth)

**14079** (BNWL-1051(Pt.1), pp 65-77) A CLIMATOLOGICAL SURVEY OF TEMPERATURE–PRECIPITATION–VEGETATION RELATIONS ON THE ALE RESERVE. Hinds, W. T.; Thorp, J. M. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

A description of the major vegetation cover types and their distribution on the ALE Reserve follows a description of the elevational transects on the Reserve. The data collected to date (temperature and rainfall from March 1968) are used to show that the mountain-valley inversion in the Hanford region intersects Rattlesnake Mountain at about 1000 ft MSL, and that the

inversion is probably more pronounced in equinoctial seasons than in solstice seasons. The microclimatic amelioration due to the inversion is pointed out. It is also shown that rainfall increases with elevation rather uniformly. An estimated precipitation efficiency (the ratio of estimated annual rainfall to estimated evapotranspiration) is calculated and this indicates a marked increase in efficiency above about 800 ft MSL, coincident with a marked alteration in floristics. (auth)

**14080** (COO-1407-33) RAIN SCAVENGING STUDIES. Progress Report No. 6. Dingle, A. Nelson (Michigan Univ., Ann Arbor. Dept. of Meteorology and Oceanography). Dec 1969. Contract AT(11-1)-1407. 97p. Dep. CFSTI.

The field project was moved from Chickasha, Oklahoma, to Clinton, Illinois. The instruments were installed at Clinton and the measurement and sampling of rain data were coordinated with collaborators at Clinton during the period May 16 to June 15, 1969. Data obtained were sparse, and opportunity for good tracer experiments using indium flares did not appear because of a severely dry season in central Illinois. Data obtained are presented in the form of tables, graphs, weather maps, and radar photographs. Measurements of the particle size distribution of the flare-generated indium tracer have given a bimodal curve. Calibration of the drop-size spectrometer has been repeated. (J.C.W.)

**14081** (ORNL-tr-2168) ENERGY DISTRIBUTION AND DOSE RATE OF THE $\gamma$-RADIATION OF RADIOACTIVE CLOUDS ABOVE GROUND LEVEL. Schmidt, A. (Frankfurt Univ. (West Germany). Institut fuer Kernphysik). Translated for Oak Ridge National Lab., Tenn., from report IKF-21. 61p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 23: 13871.

**14082** (RLO-1750-54, pp 20-4) DETECTION AND ANALYSIS OF AIRBORNE GAMMA EMITTING RADIONUCLIDES. Gilson, James E.; Forster, William O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

During Dec. 1968 to June 1969 atmospheric air samples were obtained at Albany, Ore. and analyzed for five fission products: $^{144}Ce$, $^{137}Cs$, $^{103}Rh-^{103}Ru$, $^{106}Rh-^{106}Ru$, and $^{95}Nb-^{95}Zr$. The rainfall for each 24 hr sampling period was also recorded. Data obtained from these measurements are presented. (L.C.L.)

**14083** DETECTION OF RADON IN THE ATMOSPHERE. McLaughlin, J. P.; Nolan, P. J. (University Coll., Dublin). Proc. Roy. Irish Acad., Sect. A; 68: 55-8(Dec 1969).

A method is described for measuring the radon content of the atmosphere. In this method the daughter products of radon in a sample chamber were electrostatically collected on a zinc sulphide phosphor. The subsequent scintillations due to the alpha particles from RaA and RaC' were counted by means of a photomultiplier tube and scaler. The air at the Dublin sampling site was found to have an average value of $12 \times 10^{-14}$ curies/litre. Radon values measured ranged from $3.0 \times 10^{-14}$ to $86 \times 10^{-14}$ curies/litre. The ultimate sensitivity of the instrument is governed by the background which is equivalent to a radon concentration of approximately $2.7 \times 10^{-14}$ curies/litre. Investigations were made on the effect of meteorological conditions on radon content. A study was also made on the influence of the radon content on the degree of charge equilibrium attained by condensation nuclei. (auth) (UK)

**14084** VERTICAL DIFFUSIVITY FROM RADON PROFILES. Hosler, Charles R. (Public Health Service, Raleigh, N. C.). J. Geophys. Res.; 74: 7018-26(20 Dec 1969).

Measurements of the vertical profile of atmospheric radon ($^{222}Rn$) concentration at a tower site near Washington, D. C., are interpreted in terms of vertical diffusivity ($K_z$). A mean uniform radon flux with height was derived for near-adiabatic conditions from expressions normally used to compute moisture flux; the radon flux term was assumed to apply to all meteorological conditions and was used in the conventional flux-gradient equation to yield an average vertical diffusivity for a 90-meter height interval. Average derived vertical diffusivities ranged from about $3.1 \times 10^5$ cm$^2$ sec$^{-1}$ during unstable convective periods to about $8.3 \times 10^3$ cm$^2$ sec$^{-1}$ during stable inversion periods, based on radon concentrations measured over 1- to 4-hour periods. In a gross sense the derived $K_z$ values were consistent with measured conventional meteorological and turbulence parameters. (auth)

**14085** LONG-TERM DEPENDENCE OF SURFACE FALLOUT FLUCTUATIONS UPON TROPOPAUSE-LEVEL CYCLOGENESIS. Mahlman, J. D. (Naval Postgraduate School, Monterey, Calif.). Arch. Meteorol., Geophys. Bioklimatol., Ser. A; 18: 299-311 (1969).

Because of the apparent dependence of individual surface fallout increases upon cyclogenesis in the upper troposphere, an inquiry was made as to whether the annual fluctuations in fallout intensity are thus a result of seasonal changes in cyclonic activity, and whether or not the individual shorter-period peaks are statistically related to cyclonic activity when viewed over longer time periods. This problem was examined by using an index that describes the relative amount of tropopause-level cyclonic activity in mid-latitudes, and then comparing the variations of this index with those of the area-mean fallout intensity. Since surface fallout maxima tend to appear in association with tropopause-level cyclones, 300 mb was chosen as the most representative level for the calculation. Because the maximum cyclonic intensity generally occurs within the 40° to 60°N latitude band, 50°N was chosen to be an appropriate latitude for the calculation of a series of cyclonic index values. Such a comparison revealed that the spring fallout peak cannot be explained adequately by an increase in cyclonic activity at this time of year. Shorter period increases, however, are strongly related to occurrences of intense cyclogenesis in the upper troposphere. The age-corrected fallout averaged over the area of the contiguous United States revealed the existence of a regular seasonal variation with a maximum in late spring and a minimum in late fall. The spring peak in 1964 is a factor of 2 less in 1964 than 1963, reflecting the progressive depletion of debris following the nuclear testing moratorium of December 1962. (BBB)

**14086** FALLOUT FROM THE CHINESE NUCLEAR EXPLOSION OF DEC. 27, 1968. Fahland, J. (Univ., Mainz). Z. Naturforsch.; 24a: 1832-3(Nov 1969). (In German).

Short-lived radionuclides were measured in fallout of the Chinese nuclear test of Dec. 27, 1968. The measured yield ratios of the nuclides $^{95}Zr$, $^{111}Ag$, $^{115}Cd$, $^{156}Eu$, $^{237}U$, and $^{239}Np$ were corrected for fractionation effects and compared to calculated ratios. Free parameters of the calculation such as most frequent neutron energy, time integrated neutron flux, and fission material were adjusted by means of a least square criterion. The most frequent energy was found to be 5 keV. The corresponding Maxwellian time integrated flux was $3 \cdot 10^{23}$ n/cm$^2$. In addition, a 14 MeV-time integrated flux of $1 \cdot 10^{22}$ n/cm$^2$ had to be assumed. The converted fission material was $^{235}U$ and $^{238}U$ with 15% $^{235}U$. (auth)

**14087** PRELIMINARY STUDY OF TROPOSPHERIC AND STRATOSPHERIC TRANSPORT OF RADIOACTIVE MATERIALS INTRODUCED IN THE ATMOSPHERE BY MEANS OF ATOMIC EXPLOSIONS, ON THE BASIS OF CONSTRUCTION OF PROGNOSTIC TRAJECTORIES IN AIR. Montalto, M.; D'Angiolino, G. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 33-55(Jun 1966). (In Italian).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

On the basis of the daily upper air charts at the 500, 300, and 10 mb, levels and of the respective 24 hr prognostic charts, the daily prognostic trajectories of air particles at the indicated levels were computed. The space-time origin of the trajectories was fixed at about the place and time of the Chinese nuclear tests of May 14, 1965 and May 9, 1966. Also the gradual deformation of the hypothetical clouds carried on by the trajectories was recorded. With the help of air radioactivity data, as measured at the U.S.A. and Italian stations, it was possible to check the forecast air trajectories. (auth)

**14088** AMBIENT RADIOACTIVITY DATA FROM THE CNR-AGI NETWORK. Giorgi, M.; Dalu, G. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 57-88(Jun 1966). (In Italian).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

A description is given of a typical station of the CNR-AGI network and of the procedure followed for the measurements. This procedure is discussed and some improvements are suggested which make for a better utilization of this network in the investigation of large-scale circulation. Data are given which were recorded from the beginning of the measurements until 1963. (auth)

**14089** COMPARISON BETWEEN GAMMA SPECTRA OF FALLOUT AND RAINOUT, IN NAPLES, JUNE 1965, FROM THE CHINESE NUCLEAR TESTS. Gasparini, P.; Luongo, G.; Rapolla, A. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 141-6(Jun 1966).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

Two gamma spectra are compared: one of them refers to an atmospheric dust sample collected in Naples, June 1965, the other to a soil sample picked up at the bottom of the Solfatara crater (Pozzuoli) in the same month. The two spectra showed the presence of many artificial radionuclides ascribable to the recent Chinese nuclear tests. The qualitative and quantitative differences between the two spectra, and between the obtained and the theoretical values, showed the presence of selective processes. (auth)

**14090** NEW METHOD FOR MEASURING THE ATMOSPHERIC CONCENTRATION OF RADON AND THORON. Dalu, G. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 389-98(Jun 1966). (In Italian).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

A knowledge of the variation of the radon and thoron concentration is of great interest in micrometeorology. Several authors have continuously recorded the radioactivity, making use of filters similar to those used for measuring the contamination due to nuclear explosions. Using the same method of sampling and measuring, a new method was devised for transforming the measurements of the filter activity into variation of radon and thoron concentrations. For this purpose it is necessary to introduce certain hypotheses which are generally accepted. Furthermore, this method afforded the possibility of verifying the validity of the hypotheses and of checking within what limits they are acceptable. (auth)

**14091** EXCHANGE COEFFICIENT FOR MEASURING RADON CONCENTRATIONS. Dalu, G. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 399-408(Jun 1966). (In Italian).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

Assuming the general equation which relates the radon and thoron concentrations to the meteorological parameters and the decay constants, a simplified form of the equation was derived by means of suitable hypotheses. This latter equation was integrated for different forms of the exchange coefficient as a function of the height. In this way it is possible to have a direct relation between the concentration of the radon for a certain height and the corresponding exchange coefficient. Thus a useful method is obtained for determining more precisely the exchange coefficient in conditions of light wind. (auth)

# Mineralogy and Exploration

**14092** EFFECT OF MATERIAL COMPOSITION OF ROCKS ON FORMATION OF EPIGENETIC URANIUM CONCENTRATIONS. Kashirtseva, M. F. Int. Geol. Rev.; 11: 530-8(May 1969).

Analysis of the different forms of physical composition of rocks of different U content showed that accumulations of U are confined to rocks of the pyritic geochemical type. The confinement of epigenetic pyrite and of accumulations of U to the pyritic type of rocks is evidence that the oxidation processes and production of hydrogen sulfide by bacteria are conducive to precipitation of U, as they are responsible for the steep Eh threshold at the contact between oxidized and unoxidized rocks. In prospecting for U or deposits of the infiltrational type, the physical composition of the host rocks should be considered, together with other indications, inasmuch as the rocks may be favorable or adverse to the formation of economic ores, by virtue of their inherent geochemical characteristics. Accumulations of various elements, particularly U, are favored by the presence of substantial quantities of easily oxidized minerals in the rock, particularly in rocks of the pyritic type in which the sulfide forms of iron should at least be about 0.3%. The chlorite-sideritic type, in which these forms do not exceed 0.1% of the rock, by weight, and the iron minerals are not easily oxidizable, as a whole, is not as favorable for the accumulations. Rocks in which the iron is mainly clastic and the sulfides are negligible (0.2 to 0.3%) are unfavorable for accumulations of such elements as U, Se, Mo, Pb, Fe, and others. Ore deposits of the type described are rare in nature because only in rare circumstances are all the factors essential for their development simultaneously operative. Among these factors, the physically favorable composition of the host rocks is the indispensable prerequisite. (auth)

**14093** TWO CLASSES OF REDUCING GEOCHEMICAL BARRIERS IN EXOGENIC URANIFEROUS DEPOSITS. Zelenova, O. I.; Viselkina, M. A.; Perel'man, A. I. At. Energ. (USSR); 28: 3-9(Jan 1970). (In Russian).

The formation of uranium and selenium ores takes place at the reducing barriers of hydrogen sulfide and gley deposits of stratum oxidation. The deposition of uranium, selenium, iron sulfides and sulfides of chalcophylic elements is a characteristic feature for hydrogen sulfides reducing barrier. At the gley barrier uranium and selenium are deposited, but sulfides of iron and chalcophylic elements are not concentrated there. (auth)

**14094** THE EFFECT OF FRESH WATER ON THE REDISTRIBUTION OF URANIUM IN CARBONATE SEDIMENTS. Haglund, David S.; Friedman, Gerald M.; Miller, Donald S. (Rensselaer Polytechnic Inst., Troy, N. Y.). J. Sediment. Petrol.; 39: 1283-96(Dec 1969). (RPI-3836-3).

The uranium concentration of two independent carbonate sediment sample suites was studied to establish the effect of fresh water alteration on the redistribution of uranium. Recent carbonate sands and their ancient analogs were studied in Bermuda and along the east coast of the Mediterranean Sea in Israel. The results of the uranium analyses are compared to established indicators of fresh water alteration in carbonate sediments. Interpretation of the data from both areas yields the same conclusions. As the metastable minerals aragonite and Mg-calcite are removed by fresh water from the sediment system and the sample type changes from unconsolidated carbonate sand to consolidated limestone there is a concomitant decrease in uranium content. The uranium and calcite concentrations show an inverse relation and indicate that the product of fresh water alteration, calcite, accepts less uranium than the original aragonite. The relationship between uranium and the stable carbon and oxygen isotopes for the Bermuda suite is inconclusive, whereas the same plots for the Israeli Coast suite show a direct relationship between decreasing uranium content and increasingly negative delta values. The relations between uranium and established indicators of fresh water alteration provide converging lines of evidence indicating that fresh water dissolution and replacement of marine carbonates cause a reduction, up to 50 percent over the Pleistocene samples, in total sample uranium content. (auth)

**14095** OCCURRENCE OF URANIUM IN JAPAN. Hirono, Shuichiro (Power Reactor and Nuclear Fuel Development Corp., Ibaraki, Japan). Suiyokaishi; 16: 708-10(Oct 1969). (In Japanese).

Uranium in natural water can be fixed by adsorption on some adsorbents such as carbonaceous materials, chlorite (thuringite) and heulandite. Heulandite and carbonaceous materials which have adsorbed uranium can be observed in Tono uranium deposits, and chlorite which has adsorbed uranium can be observed in Toyoda uranium deposits. Adsorption and desorption experiments of hexavalent uranium to carbonaceous materials, chlorite and heulandite reveal that uranium is adsorbed in the most amount by carbonaceous materials at pH 3 ~ 7, chlorite at pH 3 ~ 8 and heulandite at pH 5 ~ 8.5. (auth) (NSA of Japan)

**14096** URANIUM IN THE SEVENTIES. Kostuik, John. Pub. Util. Fortn.; 85: 44-50(12 Feb 1970).

A discussion of the mineral uranium and its potential as a primary energy resource is presented. The development has just begun, but at a rate that has exceeded the expectations of the proponents of nuclear energy. There have also been problems, one of which is the threat of serious future supply problems. The uranium supply situation in the seventies, as well as the use of this metal in the production of electric energy, is presented from the viewpoint of a Canadian producer. (auth)

# Oceanography

*Refer also to abstract 14171.*

**14097** (NYO-3109-40) SUMMARY OF OUR PRESENT KNOWLEDGE OF THE PHYSICAL PROCESSES OF MIXING IN THE OCEAN AND COASTAL WATERS, AND A SET OF PRACTICAL GUIDELINES FOR THE APPLICATION OF EXISTING DIFFUSION EQUATIONS IN THE PREPARATION OF NUCLEAR SAFETY EVALUATIONS OF THE USE OF NUCLEAR POWER SOURCES IN THE SEA. Okubo, Akira; Pritchard, D. W. (Johns Hopkins Univ., Baltimore, Md. Chesapeake Bay Inst.). Sep 1969. Contract AT(30-1)-3109. 159p. Dep. CFSTI.

Mathematical formulations for mixing processes in the sea are presented. Solutions for an instantaneous point-source are taken as fundamental. These solutions can be classified into two groups: radially symmetrical solutions and shear-diffusion solutions. The former may be further categorized according to a characteristic parameter involved in the solution. Shear-diffusion solutions are derived from the assumptions of uniform lateral and vertical shears in the mean velocity and of constant eddy diffusivities. A set of guidelines for nuclear safety evaluations is presented. The principle of superposition of the fundamental solution was used to formulate solutions for a variety of practical problems. Predictions with a radially symmetrical solution, i.e., O-P solution, are made for horizontal distributions of radioactivity from instantaneous sources. Boundary conditions and the effect of vertical diffusion are considered to some extent. The O-P solution is also used in the evaluations of concentration distribution from continuous sources: line source, plane source, etc. Predictions with the shear-diffusion solutions are made for the shape variation of patch from an instantaneous small-sized source and for the concentration distribution of plume from a continuous source. A mathematical model for shear diffusion from a source placed at the bottom of the sea is also presented. Conventional approaches to oceanic

mixing problems with possible applications to nuclear safety evaluation are described. These methods are still useful for a number of problems in oceans and coastal waters. Finally, box models are presented for the evaluation of large-scale mixing in the ocean and in a partially mixed estuary. (auth)

**14098** (RLO–1750–54, pp 67–70) THE VARIABILITY OF SIX RADIONUCLIDES WITH DEPTH AT TWO STATIONS OFF THE OREGON COAST IN 1968. Forster, William O.; Robertson, Dave (Oregon State Univ., Corvallis. Dept. of Oceanography).

The activities of $^{51}Cr$, $^{54}Mn$, $^{124}Sb$, $^{46}Sc$, $^{65}Zn$, and $^{95}Zr/Nb$ in water south of the Columbia River mouth were measured at 2 stations and at 6 depths from the surface to 200 m. The measurements showed that $^{51}Cr$, $^{46}Sc$, and $^{65}Zn$ are about ten times more radioactive at the surface at the station closer to the river (plume water) than at the second station. All the radioisotopes' activities decreased in a log-linear relationship when the log of the activity was plotted against depth. The percentage of $^{51}Cr$, $^{95}Zr/^{95}Nb$, $^{65}Zn$, and $^{46}Sc$ at the same stations and depth were also measured. Both stations showed a large increase in the percentage of particulate $^{51}Cr$ at depths. Another unexpected result was the extremely low (5 to 6%) percentage of particulate $^{65}Zn$. This is a ten-fold drop from the estuary-river ratios and is probably due to the exchange with the excess $Mg^{++}$ ions in seawater. In the out-of-plume station the particulate $^{65}Zn$ doesn't vary more than 30% from an average 8%. However, the in-plume station shows very low percentage (<1%) particulate of $^{65}Zn$ associated with particles rising to a maximum (11%) at 48 m and then falling again to a minimum (<1%) at 200 m. If outside the plume, the particulate $^{46}Sc$ remained approximately constant at 28%, however inside the plume, it constantly increased from surface (9%) to depth (75%). The light fission fragments $^{95}Zr/^{95}Nb$ changed in the same way as did $^{46}Sc$. (L.C.L.)

**14099** (RLO–1750–54, pp 71–4) PERCENTAGE OF SIX RADIONUCLIDES ASSOCIATED WITH PARTICLES FROM SURFACE TO 1.6 KM IN THE NORTHEAST PACIFIC OCEAN WATER. Forster, William O.; Robertson, Dave (Oregon State Univ., Corvallis. Dept. of Oceanography).

The percentages of $^{7}Be$, $^{60}Co$, $^{137}Cs$, $^{226}Ra$, $^{106}Ru$, and $^{228}Th$ associated with particles in northeast Pacific Ocean water located 350 miles west of Newport, Oregon and the activities of these radioisotopes were measured at various depths from the surface to 1600 m. The results were plotted and showed little change in radioisotope abundances at depths greater than 650 m. The total radioactivity at the surface from both the soluble and particulate fractions of these radioisotopes was approximately 1.14 pCi/l of which 70% was from $^{137}Cs$. The activities of each of the radioisotopes decreased rapidly between the surface and a depth of 350 m and changed little thereafter. (L.C.L.)

**14100** (RLO–1750–54, pp 75–7) CHANGING FORM AND LEVELS OF ACTIVITY OF SEVERAL COLUMBIA RIVER RADIONUCLIDES AS THEY MIX WITH NORTHEAST PACIFIC OCEAN WATER. Forster, William O.; Larsen, Lauren; Wagner, Jerry (Oregon State Univ., Corvallis. Dept. of Oceanography).

The total radioactivity and particulate percentage of $^{60}Co$, $^{51}Cr$, $^{54}Mn$, $^{124}Sb$, $^{46}Sc$, $^{65}Zn$, and $^{95}Zr/Nb$, which are introduced into the northeast Pacific Ocean by Columbia River water, were measured at 3 stations to determine how the form and activity levels of the radioisotopes change as they mix with the ocean water. The total activity of each radioisotope, which includes both the soluble and the particulate fractions, was shown to decrease by a log-linear relationship with distance. The slope of the decrease is a function of the mixing characteristics of the plume, physical decay of the nuclide, and other biogeochemical aspects. The percentage of these radionuclides associated with particles changes markedly as they move from a brackish environment into seawater salinites. In all cases except $^{51}Cr$ and $^{124}Sb$, the highly particulate estuarine species dropped to a fraction of its estuary value, $^{46}Sc$ (0.60), $^{51}Cr$ (0.00), $^{54}Mn$ (0.10), $^{60}Co$ (0.60), $^{65}Zn$ (0.07), $^{95}Zr/Nb$ (0.13). However, the soluble anion $^{124}Sb$ increased offshore three-fold to 7% particulate. Chromium-51 was abnormally high in the estuary at 20% particulate so the increase to 33% offshore did not appear to be much of a change but ordinarily that would be at least an order of magnitude increase. Scandium-46 remains associated with particulate material for a longer period and higher salinity than does $^{65}Zn$, which decreases rapidly from 80% particulate in the river water to 55% in the plume waters. (L.C.L.)

**14101** THE STATE OF MICROQUANTITIES OF $^{95}Nb$ AND $^{99}Tc$ IN SEA WATER. Spitsyn, V. I.; Bernovskaya, R. N.; Bogdanov, Yu. A.; Gromov, V. V.; Tikhomirov, V. N. Radiokhimiya; 11: 607–9(1969). (In Russian).

The physicochemical state of radioactive niobium and technetium in seawater was studied. It was shown that $^{95}Nb$, entering the ocean is hydrolyzed and approximately 70% of the element forms a slightly soluble colloid of niobium hydroxide and the other part remains in the dissolved state. $^{99}Tc$ in seawater remains in its initial state, dissolved. (M.C.G.)

**14102** CONCERNING THE SOURCE OF THE EXCESS $^{3}He$ IN THE SEA. Fairhall, A. W. (Univ. of Washington, Seattle). Earth Planet. Sci. Lett.; 7: 249–50(Dec 1969).

A significant fraction, if not all, of the excess $^{3}He$ found in the deep sea is attributed to decay of tritium. (auth)

## Seismology

**14103** (AD–696875) SELF-SIMILAR STRONG SHOCKS WITH RADIATION IN A DECREASING EXPONENTIAL ATMOSPHERE. Laumbach, Dallas D.; Probstein, Ronald F. (Massachusetts Inst. of Tech., Cambridge. Fluid Mechanics Lab.). Jul 1969. Contract Nonr-1841(93). 22p. (Pub–69–5). CFSTI.

The self-similar, one-dimensional flow behind a plane shock propagating upward into an exponentially decreasing atmosphere is considered. The flow is taken to be isothermal in view of the large radiation mean free paths associated with high altitudes and the intense radiation heat transfer accompanying the high temperatures characteristic of an accelerating shock wave. The equations of motion are formulated in Lagrangian coordinates and are integrated exactly for all values of the shock density ratio. Solutions are presented for the cases where the boundary conditions at the shock correspond to a supercritical shock and to a Chapman–Jouguet shock. A significant result of the analysis is that in both of these cases the shock propagates much faster than for the case of adiabatic flow. (auth) (USGRDR)

**14104** MARVEL: NUCLEAR DRIVEN SHOCK-TUBE EXPERIMENT. Glenn, H. D.; Crowley, B. K. (Univ. of California, Livermore). J. Appl. Phys.; 41: 689–97(Feb 1970).

A 2.2-kton nuclear explosive was detonated underground at one end of a 122-m long, 1-m ID horizontal tunnel at the Nevada Test Site. The purpose of the experiment was to study the hydrodynamic flow of energy down a tunnel from a nuclear explosive. This report describes the experimentation utilized to record luminosity of the shock front for the first 15 μsec and time of arrival of the shock front at specific positions along the tunnel. The observed temperature, determined from shock-luminosity data and the blackbody radiation assumption, dropped from 11.8 to 2.3 eV at times of 3.2 and 18 μsec respectively after the peak energy output of the nuclear explosion. The shock wave traversed the 122 m in approximately 4 msec, with a velocity ranging from about 13 cm/μsec near the shot point to approximately 1 cm/μsec at the far end. (auth)

# ENGINEERING

## Nuclear Explosions

*Refer also to abstracts 14054, 14055, 14103, 14104, 14122, 14132, 14483, and 14701.*

**14105** (AEC-tr-7120) MECHANICAL EFFECTS OF UNDERGROUND NUCLEAR EXPLOSIONS, MOSCOW, USSR, 1969. Translation of a Russian report. 10p. Dep. CFSTI.

Methods for predicting the mechanical effects of cratering and fully-contained, or camouflet, underground nuclear explosions are discussed. The mechanical effects of a cratering explosion include the dimensions of the visible crater, distribution of ejecta on the free surface, and seismic effects. The mechanical effects of a camouflet explosion include cavity volume, fracture zone size, degree of rock fracture, compression wave intensity, and seismic effect. The controlling parameters include the energy of the nuclear charge, the depth and volume of the placement cavity, and the physical and chemical characteristics of the surrounding media. Further experimental work for verification of these prediction methods is recommended. (L.C.L.)

**14106** (AEC-tr-7121) REVIEW OF POSSIBLE PEACEFUL APPLICATIONS OF NUCLEAR EXPLOSIONS IN THE NATIONAL ECONOMY OF THE SOVIET UNION, MOSCOW, 1969. Translation of a Russian report. 23p. Dep. CFSTI.

The feasibility of using underground nuclear explosions, both cratering and full-contained, for industrial purposes in the USSR was explored. Large unpopulated land areas, particularly those containing mineral deposits, are an important factor in contemplating such applications as mineral exploration by rock cracking, underground mining, and petroleum and natural gas production stimulation. Applications in the construction field include the building of canals, dams, reservoirs, and underground storage areas. The mechanical, radiological, and seismic effects of underground nuclear explosions and the results of tests using models or chemical explosives are discussed. Experimental data from a nuclear explosion in salt at a depth of 170 m are presented. It is concluded that cratering applications would definitely be economically advantageous and that industrial applications of fully-contained explosions are economically promising. (L.C.L.)

**14107** (CEA-R-3885) MATERIAL MOVEMENT OF MEDIUM SURROUNDING AN UNDERGROUND NUCLEAR EXPLOSION. Guerrini, Charles; Garnier, Jean-Louis (Commissariat a l'Energie Atomique, Bruyeres-le-Chatel (France). Centre d'Etudes). Nov 1969. 28p. (In French). Dep. CFSTI (U. S. Sales Only).

The results of measurements of the mechanical effects in the intermediate zone around underground nuclear explosions in Sahara granite are presented. After a description of the main characteristics of the equipment used, the laws drawn up using experimental results for the acceleration, the velocity, and the material displacement are presented. These laws are compared to those published in other countries for nuclear tests in granite, in tuff, and in alluvial deposits. (auth)

**14108** (PNE-325) PHOTOGRAPHIC AND ACCELEROMETER MEASUREMENTS OF THE SURFACE MOTION ON THE BUGGY CRATERING EXPERIMENT. Rohrer, Robert F.; Hurdlow, William R. (California Univ., Livermore. Lawrence Radiation Lab.). Aug 1969. 131p. (UCRL-50734). Dep. CFSTI.

Surface motion data as a function of time are presented for the Buggy cratering experiment, in which five nuclear charges in a line were fired simultaneously. The surface motion was measured photographically and with accelerometers. In the photographic measurements, highspeed motion picture cameras followed the motion of arrays of ground target flares over the cratering zone and of two falling mass experiments located near two of the emplacement holes. The results presented consist of graphs of displacement, velocity, and acceleration as functions of time. Observed velocities of the mount are compared with calculated predictions. (auth)

**14109** (UCRL-72175) GASBUGGY IN PERSPECTIVE. Holzer, Alfred (California Univ., Livermore. Lawrence Radiation Lab.). 14 Jan 1970. 40p. (CONF-700101-3). Dep. CFSTI.

From Meeting on Engineering with Nuclear Explosives, Las Vegas, Nev.

The Gasbuggy experiment set out to answer a number of questions: To what degree could a low-permeability, gas-bearing formation be stimulated? What were the mechanisms responsible for stimulation of gas? What were the problems of product contamination and potential ground shock damage? After two years of post-shot work, some of these questions are being answered; more precisely, pressures, temperatures and concentrations of radioactive and nonradioactive constituents of the gas are being established. However, analyzing these quantities and their dependence on variables such as flow rates in terms of a self-consistent model of all the detonation phenomena has been a difficult and slow process. The validity of such a model must be tested by data from other detonations with geologies, reservoir properties and, perhaps, explosive yields different than those of Gasbuggy. The gas stimulation projects now being planned must be capable of furnishing some of these data before they can be called experiments in the fullest sense. (auth)

**14110** (UCRL-Trans-10420) CRATERING BLASTS. Dokuchaev, M. M.; Rodionov, V. N.; Romashov, A. N. Translated by A. M. A. Mincer for Univ. of California, Lawrence Radiation Lab., Livermore, from Vzryv na Vybroc, Izdatel'stvo Akademii Nauk SSSR, Moscow, 1963. 133p. Dep. CFSTI.

Experimental and theoretical laws of the development of underground explosions in a medium of infinite extent and for an explosion close to a free surface are discussed in Part I. In Part II, the discussion of cratering blasts includes experimental methods, organization and procedures for large test blasts from 80 kg to 1000 tons, a discussion of the stages of ejection and the results, scatter of the ground material, the results of measurements of the craters, and the part played by gravity in the formation of the explosion. (J.C.W.)

**14111** (USGS-474-67) CHEMICAL AND RADIOCHEMICAL ANALYSES OF WATER FROM STREAMS, RESERVOIRS, WELLS, AND SPRINGS IN THE RULISON PROJECT AREA, GARFIELD AND MESA COUNTIES, COLORADO. Rulison-4. Larson, J. D.; Beetem, W. A. (Geological Survey, Denver, Colo.). Jan 1970. Contract AT(29-2)-474. 16p. Dep. CFSTI.

An inventory of wells and springs in the Rulison Project area was made from March 20 to April 3 and May 20 to 25, 1969 to provide background data on the quantity and quality of ground and surface waters. The detonation of the nuclear device emplaced at a depth of 8,425 feet below land surface was accomplished successfully on September 10, 1969. Following the event, selected wells, springs, and cisterns were physically examined to provide background information for evaluation of possible damage complaints. (J.C.W.)

**14112** CRATER FORMED BY GAS EROSION OF A NUCLEAR EXPLOSION VENT. Hansen, Spenst M. (Petro-Nuclear Ltd., Denver). Meteoritics; 4: 61-87(Oct 1968).

Five craters have been formed by nuclear explosions in the U. S. since 1962; data from these experiments have provided a much improved understanding of the mechanisms of crater formation. A description is given of the crater produced by the Palanquin experiment, and the gas erosional mechanism of crater formation that was observed is discussed. The crater resulting from the Palanquin experiment (a 4.3-Kt nuclear explosion detonated at a depth of 280 ft in layered trachytic volcanic rocks at the Nevada Test Site) had an unusual conical shape and dimensions of 119.1 ft radius and 78.8 ft depth. The crater volume was 46,800 $yd^3$. The mechanism of crater formation included the following steps: ejection at 450 msec of the upper part of the 36-in.-inside dia strong steel casing as a smooth plug. This resulted largely from failure of the grout bonding between the casing and the inside of the 48-in. dia emplacement hole. The casing was filled with pea gravel. The upper portion of the casing remained filled with pea gravel; venting of higher temperature, high pressure gas out of the open emplacement hole eroded the sides and caused a progressive increase in the size of the vent opening. The vent dia was 30 ft at 525 msec, 90 ft at 750 msec, and 210 ft at 1.5 sec; fallback and slumping of adjacent weakened and fractured rock partially filled the true crater. A rubble mound had been predicted instead of a crater. Experience from other underground experiments along with preshot calculations indicated that at the scaled depth of burst of Palanquin neither the surface spall nor the gas acceleration from a nuclear explosion is sufficient to eject the rubble from the true crater. The cratering mechanism of gas erosion of a vent, as observed at Palanquin, is significantly different from the spalling mechanism dominant at the Danny Boy experiment, and the gas mound acceleration mechanism dominant at the Sedan experiment. (BBB)

**14113** DETECTION OF UNDERGROUND NUCLEAR EXPLOSIONS. Chevallet, Michel. Sci. Avenir; No. 271, 738-45; 774(Sep 1969). (In French).

The distinction between a seism and an underground nuclear explosion, though subtle, may be made by an original French technique even at a distance of thousands of kilometers. Principal types of waves registered by an explosion are noted as P and S, and the Love and Rayleigh surfaces waves. The variation of amplitude of the P wave with distance from the epicenter is noted, and propagation through various components of the earth (crust, mantle, nucleus) is detailed. Localization of the epicenter by evaluation of the S wave pattern is described. Possible camouflage methods are outlined. These may be circumvented by amplification of signals at a position where the background level of microseisms is low, such as the Sahara, where the level is 5 or 6 Å. Analysis of the range of frequencies registered may also be used to detect explosions. The combination of data received from several stations may also be used to reduce noise. Criteria for distinction include analysis of signal shape, and new methods of treating the pressure wave and the Rayleigh wave. (BBB)

**14114** DETECTION AND LOCATION OF AN ATMOSPHERIC NUCLEAR EXPLOSION BY MICROBAROGRAPH ARRAYS. Varghese, T. G.; Kumar, V. (Bhabha Atomic Research Center, Trombay, India). Nature (London); 225: 259-61(17 Jan 1970).

Sensitive microbarographs which respond to atmospheric pressure variations of a few tens of $\mu$ bar at periods ranging from 30 sec. to 5 min. can detect pressure waves set up by atmospheric explosions, but wind eddies and internal gravity waves of meteorological origin produce similar disturbances, and the basic problem is to distinguish the signals on the basis of dispersive patterns, vector velocity and frequency structure against this background. Array techniques have been used successfully to detect wave disturbances and trace their origin in several physical fields. Two or more well separated arrays will enable the source to be located by triangulation with an accuracy depending on the precision of the direction estimates and hence on the degree of correlation of the signal to each array and the number of contributing arrays. The intersection of the great circles corresponding to the wave vectors to two arrays, however, gives a rough estimate of the source location. This procedure was used to deduce the location of the Chinese atmospheric explosion of Dec. 27th 1968, and to examine how the signal coherence varied with distance, the accuracy of phase velocity and bearing depending on the degree of coherence between the signal pairs and the distance between them in relation to the source. The pressure waves were detected by two tripartite arrays of microbarographs separated by about 1,670 km. Results are shown graphically and discussed. The results suggest the possibility of locating large atmospheric explosions by a group of well separated microbarograph arrays, and of accentuating their acoustic gravity wave signals by phased summation using an array with an aperture of 25 to 30 km. and spacing of 5 km. (UK)

**14115** PEACEFUL NUCLEAR EXPLOSION SERVICES FOR DOMESTIC AND FOREIGN USERS. HEARINGS BEFORE THE JOINT COMMITTEE ON ATOMIC ENERGY, CONGRESS OF THE UNITED STATES, NINETY-FIRST CONGRESS, FIRST SESSION, MAY 8, 9, AND JULY 17, 1969. Washington, D. C.; Joint Committee on Atomic Energy (1969). 763p. GPO $3.25.

## Facilities and Equipment

*Refer also to abstracts 14174, 14671, 14719, 15200, 15212, 15237, 15739, and 16328.*

**14116** (BARC–396) RECIRCULATING ARGON ATMOSPHERE DRY BOX FOR HANDLING PYROPHORIC AND HYGROSCOPIC MATERIALS. Sood, D. D.; Hariharan, A. V. (Bhabha Atomic Research Centre, Bombay (India)). 1969. 12p. Dep. CFSTI (U. S. Sales Only).

The construction and operation of a recirculating argon atmosphere dry box for handling pyrophoric and hygroscopic materials are described. The system utilizes molecular sieves and hot calcium getter to remove moisture, oxygen, and nitrogen from the argon atmosphere of the dry box. The entire set-up is incorporated with pressure switches and safety relays for continuous operation. The dry box atmosphere purity is continuously monitored for moisture and total impurity. These are <5 ppM $H_2O$ and <50 ppM $N_2 + O_2$. (auth)

**14117** (BARC–414) APPLICATION OF THEORY OF FILTRATION ON A SPECIFIC QUALITY OF ASBESTOS. Khan, A. S.; Ramachandran, S.; Amalraj, R. V. (Bhabha Atomic Research Centre, Bombay (India)). 1969. 27p. Dep. CFSTI (U. S. Sales Only).

Next to glass fibre, asbestos is the most suitable material for the production of high efficiency air filters which are required for meeting the ever increasing demands of defense, nuclear plants, electronics and other industries. Even though the asbestos is not the exact substitute for the glass fibre, at present, this is the only material that can replace glass fibre, the import of which will be difficult at times of emergencies. The pressure drop characteristics of one of the typical Indian asbestos fibre which was found to be a good filter material are studied. The behavior of this material with reference to the widely accepted theories of resistance across the fibrous beds is discussed in the light of experimental data. (auth)

**14118** (BNL–13810) COMPACT SERVO MASTER-SLAVE MANIPULATOR WITH OPTIMIZED COMMUNICATION LINKS. Flatau, Carl R. (Brookhaven National Lab., Upton, N. Y.). [1969]. 28p. (CONF-691102–22). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

A compact, bilateral force reflective servo manipulator has been developed for use in the confined environment of high-energy particle accelerators. The compactness is achieved by placing the dc servo motors and all other servo components within the manipulator arms. By use of explicit force feedback in addition to the customary position feedback, reflected friction is reduced so that sensitivity and feel are improved. Potential slave-to-master distance and slave mobility are improved by optimization of communication links. These are reduced to 15 channels per manipulator arm. (auth)

**14119** (BNWL–1051(Pt.1), pp 46-51) PARTICLE COLLECTION EFFICIENCIES ON WIRES. Sehmel, G. A.; Schwendiman, L. C. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Collection efficiencies of monodispersed 4 to 27 $\mu$ uranine particles were determined for 0.020 to 0.064 in. diameter wires for air velocities from 8.6 to 33.1 ft/sec. The wires were coated with a tacky film. The collection efficiencies are a complex function of particle size, wire diameter, Reynolds number, Stokes number, and wire surface area covered by previously impacted particles. For low coverage from 0.1 to 10% an asymptotic correlation is shown as a function of Stokes number. This asymptote is near the upper experimental limit of published collection efficiency data. When greater than about 10% of the available surface is covered with particles, the collection efficiencies are less than those indicated in published correlations. The disagreement in published efficiencies may be caused by failure to account for wire surface area coverage. (auth)

**14120** (BNWL–1051(Pt.1), pp 62-4) MICROMETEOROLOGICAL INVESTIGATIONS ON THE ALE RESERVE. Hinds, W. T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

The design of an inexpensive and accurate anemometer using ducted air fans is discussed, and the accuracy and calibration with respect to standard cup-type anemometers are shown. The Self-Orienting Fan Anemometers (SOFA) are shown to agree within ±2% between themselves, and to agree within about ±3% with the cup anemometers over a range of wind speeds from about 0.5 to more than 7 m/sec. Each SOFA costs about $80 for parts and takes about an hour for assembly. (auth)

**14121** (CEA-R–3783) SUPERCONDUCTING CURRENT GENERATORS. Genevey, Pierre (Commissariat a l'Energie Atomique, Limeil-Brevannes (France). Centre d'Etudes). Jan 1970. 114p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Univ. of Paris, Faculte des Sciences, France.

After a brief summary of the principle of energy storage and liberation on superconducting coils, two current generators are described: a flux pump and a superconducting transformer. They are used for storage experiments of 25 kJ and 50 kJ, and currents created by both of them vary between 600 and 1400 A. The efficiency of the superconducting transformer (95%) is much higher than that of the flux pump (which lies between 40 and 60%). The superiority of the transformer over the flux pump to create large currents is shown. Both generators could be developed into more powerful units. (auth) (France)

**14122** (CONF-690824(Summ.)) ELECTROMAGNETIC PULSE PROBLEMS IN CIVILIAN POWER AND COMMUNICATIONS. Summary of a Seminar held at Oak Ridge National Laboratory, August 19–21, 1969. (Atomic Energy Commission, Washington, D. C. Office of Civil Defense, Washington, D. C.). 8p. Dep. CFSTI.

Results of electromagnetic pulses (EMP) generated by nuclear explosions are briefly described. The energy density in the pulse is sufficiently great so that it is possible for damage or malfunction to occur in electrical or electronic equipment. The EMP damage from a single detonation can occur at distances hundreds

of miles from the detonation point. Five conference sessions on power system design; EMP characteristics and effects; warning and communication system design; EMP systems analysis; and status of EMP threat to civilian power and communications are briefly summarized. (J.C.W.)

**14123** (EUR-4280(Vol.1), pp 253-71) STRESS ANALYSIS AND STRUCTURAL INTEGRITY OF PRESSURE VESSELS. Schrage, H. P. (Fried-Krupp Universalbau, Essen (West Germany)). (In German).

A computer program for stress analysis of rotational symmetric, cylindrical, thick-walled pressure vessels was formulated to be used in pressure vessel development. It was to be verified on the basis of test results on a 1:5 concrete scale model. (J.S.R.)

**14124** (GEAP-10048) PLUGGING INDICATOR OPERATION: SODIUM MASS TRANSFER PROGRAM. Collins, G. D. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Sep 1969. Contract AT(04-3)-189. 36p. Dep. CFSTI.

Research directed toward development of plugging indicators for sodium loops is reviewed. Discussions of plugging indicator operation and the double plugging break in high-temperature sodium systems are discussed. Details of plugging indicator design and operation in mass transfer loops are given. Information is included on automatic oscillating plugging indicators. (J.R.D.)

**14125** (IA-1200) THE FAST SHUTTLE RABBIT IRRADIATION FACILITY. PART I. DESCRIPTION AND OPERATION. Wiernik, Miguel (Israel Atomic Energy Commission, Yavne. Soreq Nuclear Research Center). Oct 1969. 15p. Dep. CFSTI (U. S. Sales Only).

The Fast Shuttle Rabbit Facility used at Soreq for work with very short-lived nuclides is described. The pneumatic system, the automatic control and the counting equipment are described. Operating instructions and examples of different types of measurements are given. Several possible improvements are discussed. (auth)

**14126** (LMEC-69-30) LIQUID METAL ENGINEERING CENTER (LMEC). Semiannual Technical Progress Report, January-June 1969. (Atomics International, Canoga Park, Calif. Liquid Metal Engineering Center). 30 Nov 1969. Contract AT(04-3)-700. 253p. Dep. CFSTI.

Activities at the LMEC were directed toward support of the LMFBR during the period. Progress is reported on support projects in codes and standards, maintenance and malfunction analysis, quality assurance, operation of sodium components test installation, liquid metals information center, sodium pump test facility, sodium seal testing, sodium bearing testing, precision mechanisms testing, steam generator performance, instrument testing, metallurgical research, and operation of test loops. (J.R.D.)

**14127** (N-69-40196) SUPERCONDUCTIVE 7.2-TESLA FOUR-MAGNET ASSEMBLY. Summary Report. Schrader, E. R.; Del Grosso, R. (Radio Corp. of America, Harrison, N. J.). Oct 1969. Contract NAS3-7928. 77p. (NASA-CR-1474). CFSTI.

The design, fabrication, and testing of a system, consisting of four magnets and a Dewar, that develops 7.2-teslas in a 50.8-cm-diameter bore is described. The design of these magnets was based upon the use of $Nb_3Sn$ superconductive ribbon wound in layer form with associated techniques that had proved successful in many previously constructed high-field magnets. Modular construction was used to contain mechanically the large forces that develop and to facilitate winding, powering, and testing of subgroups of coils. Specific superconductors were designed for use in local regions of the magnet to allow for differing requirements of current-carrying capacity at the field ranges and for varying hoop stresses. The combined use of these concepts culminated in the superconductive magnet described. (auth) (STAR)

**14128** (NYO-841-21) IN-PLACE TEST FOR IODINE REMOVAL SYSTEMS IN NUCLEAR FACILITIES. Viles, F. J. Jr.; Weker, R. A.; Goldin, A. S. (Harvard Univ., Boston, Mass. Harvard Air Cleaning Lab.). Jan 1970. Contract AT(30-1)-841. 46p. Dep. CFSTI.

A simple in-place test for filter efficiency in removing iodine has been developed. The test is suitable for field application and has been successfully tested in the field. The test involves passage of stable elemental iodine ($I_2$) through the filter, with upstream and downstream sampling on copper beads. Iodine is removed quantitatively by the beads and is recovered from them by washing with ammonium hydroxide. The wash solution is passed through a cation-exchange resin column to remove copper and the iodine is determined in the column effluent by its catalytic effect on the reaction between tetravalent cerium and arsenite. The sensitivity of the analytical method is of the order of 0.001 $\mu$g of iodine. With a 50-liter air sample (30 minutes at a flow rate of 1.67 liters per minute), the overall sensitivity is about $10^{-5}$ ppM. (auth)

**14129** (NYO-3930-6) LIQUID METAL BEARINGS TECHNOLOGY FOR LARGE, HIGH TEMPERATURE SODIUM ROTATING MACHINERY. Progress Report, February 1-October 31, 1969. Arwas, E. B.; Hoogenboom, L.; Kissinger, C.; Newell, R.; Smalley, T.; Waldron, W. D. (Mechanical Technology Inc., Latham, N. Y.). Dec 1969. Contract AT(30-1)-3930. 57p. (MTI-70-TR-7). Dep. CFSTI.

During the report period, the analysis was programmed for plain and grooved bearings and a design data handbook was prepared covering partial arc bearings, axial grooved bearings, shrouded step bearings and tilting pad bearings. In earlier work, the effort on the proximity transducer had been directed towards detail design and experimental evaluation of the transducer components. During the report period, effort was devoted to finalization of the proximity transducer assembly detail design, evaluation of prototype transducer with a conducting medium in the probe-target gap, development of the electronic system, evaluation of core and target materials, and evaluation of the transducer-electronic system in a high temperature sodium environment. The design of a film pressure transducer was finalized and evaluated at temperatures up to 1200°F. Eight complete transducers were fabricated for use in the bearing tests. The pressure transducer uses the standard Wayne-Kerr electronic amplification system. The specifications of the sodium bearings test rig were defined earlier and the design of the test system was made, including conduct of the rotor-bearing dynamics, stress, and thermal analyses. During the current period, all design and analyses were completed, the major components were ordered and installation of the test equipment was conducted. The test rig support structure was designed, fabricated, and installed in the test facility. The sodium circulation (oxygen indicating and control) loop was procured and installed. All the major process and test rig controls and equipment components were also received and installed in the control room. (J.R.D.)

**14130** (UCRL-71559) REMOTELY OPERATED CATHODIC ETCHER. Garrison, J. C.; Johnson, J. M.; Albrecht, E. D. (California Univ., Livermore. Lawrence Radiation Lab.). 27 Jun 1969. 12p. (CONF-691102-18). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

A production-type cathodic etcher of previous LRL design with a history of several years of successful operation has been redesigned for hot cell application. Extensive changes were made in the electrical insulation of components of the etching assembly to virtually eliminate arcing during etching. The etching assembly was unitized to provide for rapid remote insertion of specimens by master-slave manipulators. Periodic remote disassembly was simplified through design modifications which allowed for two-finger manipulation. Vacuum and argon pressure valves were electrically actuated for remote operation, and safety interlocks were installed between the vacuum and electrical systems. (auth)

**14131** (UCRL-71561) "WINDOWLESS" MACRO-CAMERA FOR HOT CELL USE. Albrecht, E. D.; Johnson, J. M.; Stearns, E. H. (California Univ., Livermore. Lawrence Radiation Lab.). 2 Jul 1969. 8p. (CONF-691102-15). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

A macro-camera having a magnification capability from 2 to 30× has been designed and built for use in a $\beta$-$\gamma$ Hot Cell facility. Specimens and parts up to 10 curies and no larger than 2 in. × 2½ in. in size can be photographed. The camera assembly is mounted on the cell roof and inserted into the cell through a sliding lead door prior to use. A remotely operated stage, permanently installed within the cell, provides accurate specimen positioning via x, y, and z motions. (auth)

**14132** (UCRL-72122) CONTROL OF THE DYNAMIC ENVIRONMENT PRODUCED BY UNDERGROUND NUCLEAR EXPLOSIVES. Bernreuter, D. L.; Jackson, E. C.; Miller, A. B. (California Univ., Livermore. Lawrence Radiation Lab.). 10 Dec 1969. 17p. (CONF-700101-2). Dep. CFSTI.

From Meeting on Engineering with Nuclear Explosives, Las Vegas, Nev.

Methods used to protect trailer-housed sensitive electronic recording equipment against shock damage during underground nuclear explosions are described. This control of the dynamic environment produced by underground nuclear explosions is important in order to obtain valid measurements, especially for data taken near surface ground zero. Three classes of events, over-buried, fully contained, and cratered, were considered. The

effects of different geologies on ground motion are discussed. The fragility of the measuring equipment and its support system is analyzed. A pneumatic shock isolation system, useful with relative small ground motions, is described. A universal guided column system developed for very large, 2 to 12 ft vertical displacements, is discussed in detail. A third system for ground motions of less than 10 fps which uses styrofoam and plywood crush pads, but no guiding columns, is discussed. The special requirements for minimizing shock effects to high towers or other tall elastic structures are mentioned. (L.C.L.)

**14133** SAFETY AND FAILURE OF COMPONENTS. Conference Held at Sussex, England, 3rd–5th September 1969. London; Institution of Mechanical Engineers (1969). 211p. (CONF-690934).

Thirty papers were presented at the conference. A separate abstract was prepared for one of the papers. The remainder discuss the reliability of mechanical engineering structures and components and investigate the cause and effect of failures. (UK)

*For an abstract of one paper see: 14718.*

**14134** FIELDS AND FIRST ORDER PERTURBATION EFFECTS IN TWO-DIMENSIONAL CONDUCTOR DOMINATED MAGNETS. Halbach, K. (Univ. of California, Berkeley). Nucl. Instrum. Methods; 78: 185-98(1970).

General expressions are given for the field and its expansion coefficients produced by a two dimensional conductor structure surrounded by iron with a circular inside boundary. Saturation effects are described in terms of the tangential field at that boundary. The effects of the following types of perturbations are discussed: displacement, rotation and error excitation of a conductor, change of conductor shape, and modification of the inside contour of the iron. A design criterion is given to minimize the error fields associated with a displacement of the iron shell relative to the conductor structure. Expressions for the force and torque acting on a conductor are derived both for the unperturbed and perturbed magnet. Formulae are presented that allow convenient and fast evaluation of pertinent quantities with a computer when the structure is too complicated for hand computations. (auth)

**14135** FUEL CELL SYSTEM FOR UNDERWATER WORK. Shimoji, Perry (California State Coll., Long Beach). Mar. Technol. Soc. J.; 3: 37-8(Jul-Aug 1969).

A systematic study was made of 4 feasible power sources, including a nuclear-powered unit. It was concluded that the fuel cell system had the best performance potential within the limited economic scope of a nongovernmental financed agency. Nuclear power was accepted as the ultimate in pure power output and longevity, but considering the premise that it is undesirable psychologically and physically for man to stay underwater for more than 168 hr at one time, the use of a nuclear powerplant is unnecessary for the type of work the described submersible would be doing 99% of the time. A nuclear powerplant was considered too space consuming. A powerplant this size would mean the submersible would have to be larger, causing a further restriction on maneuverability. More important, the cost would be excessively high. It was decided that nuclear power was unfeasible for the submersible in question. The fuel cell powerplant, though also costly, had the most potential for the planned work submersible system. Its advantages would overshadow the cost in the system's ability to function proficiently under adverse conditions. (BBB)

**14136** AN INEXPENSIVE, EASILY WOUND, SUPERCONDUCTING MAGNET FOR DIP EXPERIMENTS. Merrill, John R. (Dartmouth Coll., Hanover, N. H.). Rev. Sci. Instrum.; 41: 24-5(Jan 1970).

A design for a small superconducting magnet is presented. The magnet is used for dip experiments into a storage Dewar with the access tube removed from the neck. The solenoid is corrected by means of two extra coils wound on the outside. Correction coils increased the usable volume over which the field is uniform to 0.1% by a factor of about 50. The magnet is uniform to 0.1% over the full radial bore and for almost 2 cm along the axis. All the information necessary to wind the magnet is given; the magnet reported was wound by novices. The total cost of the magnet was about $20; the magnet achieved more than 15 kG. (auth)

**14137** COST ANALYSIS OF LARGE EVAPORATIVE TYPE COOLING TOWERS. Chatfield, D. L.; Streeton, D. F. (Suiselectra, Engineers and Consultants, Basel). Kerntechnik; 11: 649-52(Nov 1969).

A method is given for predicting the costs of large evaporative-type natural and mechanical draft cooling towers as functions of the main design parameters. The costs and parameter factors are also expressed analytically for use in power plant optimization programs. (auth)

**14138** PRINCIPLES AND CONSTRUCTION OF LARGE COOLING TOWERS. Chatfield, D. L.; Streeton, D. F. (Suiselectra, Engineers and Consultants, Basel). Kerntechnik; 11: 647-8(Nov 1969).

A brief review on cooling principles and design parameters of natural-draft type and induced-draft type cooling towers is given. (auth)

**14139** ON THE POWERED AIR-PURIFYING RESPIRATOR FOR RADON DAUGHTER PROTECTION. Kurosawa, Ryuhei (Waseda Univ., Tokyo). Waseda Daigaku Rikogaku Kenkyusho Hokoku; No. 45, 17-26(Sep 1969). (In Japanese).

To protect from the leakage of an air-purifying respirator coming from imperfect action of the exhaust valve and/or misfit of mask facepiece, a pressurized type of air-purifying respirator was developed. The powered air-purifying respirator which protects against inhalation of radon daughters, was constructed by the assembly of motor-blower, filtrating unit, flexible tubes and half mask facepiece. The filtrating unit of the respirator consists of the GL-filter of 725 $cm^2$ in total surface area. Intrinsic penetrating factor for the radon daughters (mode diameter of the particles: 0.05 to 0.1 $\mu m$) of the GL-filter equals 0.15% at a flow rate of 90 to 100 l/min. The flowrate of the motor-blower under the powered air-purifying operation (at a total static pressure of 10 mm of water) is estimated about 95 l/min with the characteristic curves of the motor-blower. Polonium-218 concentration in the lung air (breathed with the powered air-purifying respirator) is estimated as $3.0 \times 10^{-2}$ Cn (Cn: concentration of radon) under consideration of the $^{218}Po$ generation from the inhaled radon in worker's lungs. The above calculation agreed with the experimental results. The over-all protection factor of the powered respirator for the radon daughters is as follows under the three standpoints: the comparison between the concentration of the primary particle of $^{218}Po$ in environmental air and that of the existing air in lung of the worker using the respirator: protection factor equals 5 to 6; the comparison of the hazard evaluation of $^{218}Po$ in air between environment and the lung of the worker using the respirator, considering the difference of the attaching rate of $^{218}Po$ to inner surface of the respiratory organs: protection factor equals 26 to 31; and the comparison of potential radiation energy of the air containing radon daughters between environmental air and lung air of the worker using the respirator: protection factor equals 42. (auth) (NSA of Japan)

**14140** IMPROVEMENTS RELATING TO IRRADIATION EQUIPMENT. (to Leybold-Heraeus-Verwaltung GmbH). British Patent 1,178,214. 21 Jan 1970. Priority date 11 Feb 1967, Germany.

A design is given of a versatile irradiation device composed of the chamber, an associated storage chamber for individual radiation source carrier bodies and many inactive spacing bodies, and a guide tube which is stationary or movable. The guide tube is deformable. The design can be assembled or disassembled by hydraulic or pneumatic feeding apparatus which is conventional, but may be effected in the reverse order. (J.C.W.)

**14141** THREE YEARS' EXPERIENCE IN GAR 1 OPERATION. Suckow, W. (Zentralinisitut fuer Kernforschung, Rossendorf, Ger.). Isotopenpraxis; 5: 361-6(Sep-Oct 1969). (In German).

The experiences gained in a three years' operation of the ZfK Rossendorf irradiation rig GAR 1 are discussed. After giving a short review of the technological parameters of the plant the essential changes and supplements introduced are discussed. Technological problems which, to some extent, must yet be solved, are indicated. New results are presented. Problems of dosage, field of use, economical aspects and staff are taken up. Finally, a review of the future aspects of the rig is given. (auth)

**14142** TURBO-GENERATORS FOR THE MIHAMA ATOMIC POWER STATION. Oishi, Norio (Mitsubishi Electric Corp., Kobe, Japan). Karyoku Hatsuden; 20: 536-48(Jun 1969). (In Japanese).

No. 1 turbo-generator for the Mihama atomic power station of Kansai Power Company was constructed by the Mitsubishi Electric Corp. No. 2 turbo-generator is now being built. The generators feature cylindrical revolving-field with internal cooling, brushless exciters, and a terminal voltage of 500 V. The world situation of atomic power generation, characteristics of the tetrapole turbo-generator, methods of cooling in large-capacity generators, and the construction criteria of the generators are described. The results of tests on the No. 1 turbo-generator are given. (NSA of Japan) (TSS)

**14143** THE ELAN II B SOURCE MANUFACTURING UNIT. Courouble, J. M. (CEN, Saclay, France). Bull. Inform. Sci. Tech. (Paris); No. 142, 3-5(Nov 1969). (In French).

ELAN II B, built on the La Hauge Center and coupled with ELAN II A (Marcoule), is intended for the production of sources of cesium extracted from fission product solutions. At the same time the series of cells designed for the manufacture of these sources is equipped with the material necessary for the preparation of strontium-90 sources to 100 mm dia. The series includes three large cells of which the last, with two working stations, is specially equipped to handle and remove material of great weight (20 tons maximum) and size, for example, a strontium thermoelectric generator. (auth)

**14144** CHOOSING THE RIGHT EQUIPMENT FOR DUST CONTROL AND AIR CLEANING. Filtration Society's Conference September 23–25, 1969, at London. Croydon, Eng.; Filtration Society (1969). 66p. (CONF-690935).

Included are 12 papers on gas cleaning and air pollution control, clean rooms, dust control in working areas, and testing and performance of air filters. A separate abstract was prepared for one paper. (H.D.R.)

*For an abstract of one paper see: 16328.*

**14145** SYSTEM AND METHOD FOR REMOTE CONTROL OF A RADIOACTIVITY LOGGING TOOL. Buck, Henry M.; Hoyer, Wilmer A. (to Esso Production Research Co.). U. S. Patent 3,492,481. 27 Jan 1970. Filed 14 Oct 1966.

A surface-operated radioactive well logging system which permits remote control of various combinations of operating modes of the source and detector of a radioactivity logging tool suspended in a borehole is described. An ac operating power surface source of a selected frequency is transmitted down the cable on which the logging tool is suspended to operate the logging tool. The neutron generator is capable, when supplied with operating power, of bombarding subsurface strata with neutrons and the radiation detector is capable, when supplied with operating power, of operating in a gated mode of operation and in a continuum mode of operation. One subsurface switch has one position in which operating power is supplied to the neutron generator and another position in which the supply of operating power to the neutron generator is cut off. Another subsurface switch has one position in which the radiation detector operates gated and another position in which the radiation detector operates continuously. Control power is transmitted down the cable to control operation of the neutron generator and radiation detector. Such control power when supplied to the one switch and when supplied to the other switch, changes the positions of these switches. A subsurface time delay switch has one position capable of supplying control power to the one switch and another position capable of supplying control power to the other switch, the time delay switch being energized by the operating power to actuate and change the position of the time delay switch after a selected time delay. (Offic. Gaz.)

**14146** FIRST 200 GRAMS OF Pu EXTRACTED IN JAPAN. JAERI'S REPROCESSING TEST PROJECT. 2. Aochi, Tetsuo (Japan Atomic Energy Research Inst., Tokai). Genshiryoku Kogyo; 15: No. 12, 67-9(Dec 1969). (In Japanese).

The design of the facilities for treatment of highly radioactive material was started in June 1959. The facilities were installed in the mock-up laboratory in Oct. 1960. The operation of the facilities was carried out by 6 persons, and the melting of aluminum and uranium was tested. Various problems occurred in uranium melting. In the operation of the extraction tower, the maintenance of constant volume, the action of the pulsator, and the detection of the interface in the tower were very difficult. Some vinyl pipe melted due to solvent reactions, and the contamination by uranium became inevitable, therefore, the test was abandoned. The housing for the hot cave was completed at the end of 1962. The moving of the facilities from the mock-up laboratory to the hot cave housing was finished in Feb. 1963. The facilities for transporting used fuel and specimens to be analyzed were installed. Ten analyzing cells were completed at the end of 1962. The major problems of the mock-up test were the insufficiency of melting capacity, the air lock in piping system, and the machinery for transporting liquids. (NSA of Japan)

**14147** SHIELDED APPARATUS FOR EFFECTING IRRADIATION OF MATERIALS. Latzer, Beda (to Sulzer Brothers Ltd.). U. S. Patent 3,493,756. 3 Feb 1970. Priority date 1 Jun 1964, Switzerland.

An apparatus for exposing material to radiation, such as gamma rays for example, with shielding from the environment is described. The apparatus includes a radiation-absorbing mass having a curved passage of circular cross section extending therethrough. A cylindrical enlargement is formed in the mass about and communicating with this passage between the ends. A movable member is provided in the form of a ring, also made of radiation-absorbing material, and having recesses formed therein for the reception of material to be irradiated. This ring fits in and has substantially the same cross-section as the passage through the absorbing mass, and by motion with respect to that mass the recesses or cavities in the member can be brought into the enlargement mentioned above within which radiation sources are provided. In particular, there is shown a support having the shape of a squirrel cage which is rotatably disposed in this enlargement, surrounding the movable member and having rod-like radiation sources about its periphery. A channel extends from the enlargement to the exterior of the absorbing mass in position to permit withdrawal and replacement of the radiation sources. (Offic. Gaz.)

**14148** SUPERCONDUCTING ELECTROMAGNETS. Asesio, P.; Bronca, G. (CEA, Saclay, France). Ann. Mines; 34-8(Jan 1970). (In French).

Using superconducting electromagnets, magnetic fields up to 10 or 12 teslas can be attained in air, without Joule losses and with an equipment whose volume is smaller than that of conventional electromagnets. On the other hand, difficult problems such as these related to the helium liquefier, use of cryostats, removal of energy in case of emergency, and magnetic shielding require solution. These problems are pointed out and some examples of superconducting electromagnets being developed or already in service are presented. (auth)

**14149** INJECTOR FOR RADIOACTIVE GAS. Glenn, James J. Jr. (to Triangle Service, Inc.). U. S. Patent 3,493,757. 3 Feb 1970. Filed 2 May 1966.

In order to calculate the amount of gas which is flowing into an oil well from the surrounding strata, a gas is injected through an appropriate tool into the casing of the oil well and that tracer gas is subsequently detected at a remote point from its injection; thus determining the velocity of the incoming gas and, consequently, the amount of gas which is flowing into the bored hole of the oil well. (Offic. Gaz.)

**14150** NEUTRON IRRADIATION APPARATUS. Haram, S. A. (to Nuclear Materials and Equipment Corp.). Canadian Patent 829,412. 9 Dec 1969.

Apparatus for the study and investigation of neutron phenomena is described. It consists of a cylindrical shell of material for reducing the energy of neutron flux and a cylindrical core of neutron-moderating material removably disposed in the shell. The core has several axial passages which are separated from each other by the neutron-moderating material. There are means for removably placing neutron sources in the passages, and materials to be irradiated by the neutrons. The spaces, in which the sources and the material are inserted, are selectably interchangeable. The shell thickness is sufficient to absorb neutrons from the source to preclude injury to personnel using the apparatus. (Canada)

**14151** SOURCE REGIME OF AN IRRADIATION FACILITY PROVIDED WITH FUEL ELEMENTS. Suckow, W. (VEB WTZ Medizin- und Labortechnik, Rossendorf, Ger.). Isotopenpraxis; 5: 413-19(Nov 1969). (In German).

The comparatively rapid and non-uniform decay of fuel element gamma radiation calls for determining the optimum source regime in the utilization of reactor fuel elements as radiation sources. Characteristics are derived with the aid of which the optimum conditions can be determined. All the technologically interesting types of source regime were investigated. Measures to obtain high gamma yield and a good time stability as well as characteristic values of these two quantities were derived. The conditions for optimum source regimes are given. (auth)

**14152** A LAMP SUPPORT FOR A SEALED ENCLOSURE. Baudoin, Jean-Claude; Canut, Andre (to Commissariat a l'Energie Atomique). British Patent 1,179,540. 28 Jan 1970. Priority date 20 Dec 1967, France.

A design of a solid block support for an electric lighting system in an enclosed facility in which there are radioactive materials is presented. During the remote manipulations in the enclosure, the presence of the lighting or the operations of removing or replacing the lighting does not affect the tightness of the enclosure. (J.C.W.)

## Heat Transfer and Fluid Flow

*Refer also to abstracts 14042, 14124, 14126, 14167, 14706, and 14901.*

**14153** (AI-AEC-12906) ANALYSIS OF THE STATISTICAL DISTRIBUTION OF INCIPIENT BOILING. Landoni, J. A. (Atomics International, Canoga Park, Calif.). 31 Dec 1969. Contract AT(04-3)-701. 31p. Dep. CFSTI.

A recent study of boiling initiation in sodium flowing in a heated channel has shown that a statistical distribution of bulk superheat temperatures is obtained for otherwise fixed experimental conditions. The distribution of incipient boiling cases versus wall superheat appears to be a Poisson type distribution with a definite asymmetry. The departure from a Gaussian distribution is noticeable, however, and it can be speculated that the maximum superheat values are not firm values, but might be exceeded when more data are available. This possibility leads to a theoretical investigation of the observed statistical distribution. The Kolmogorov equation was combined with the equations for all-liquid thermal balance and used to analyze a typical distribution of incipient boiling cases. It is shown that the distribution is non-Poissonian and that for the situation prevailing in the LMFBR, the likelihood of incipient boiling at temperatures above the observed maximum wall superheat is remarkably low. (auth)

**14154** (CEA-Bib-170) FRICTION COEFFICIENT IN SINGLE-PHASE TURBULENT FLUID FLOW WITH HEAT TRANSFER. Costa, Jean (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). 1969. 21p. (In French). Dep. CFSTI (U. S. Sales Only).

The different correlations of the $f_H/f_{iso}$ ratio (friction coefficient with heat transfer divided by the isothermal friction coefficient) given in the literature are reviewed and compared for a specific example. A dispersion of about ±20% on either side of the average value was found. (auth)

**14155** (NYO-1480-135) INERTIAL RANGE FLOW AND TURBULENT CASCADES. Chorin, Alexandre Joel (New York Univ., N. Y. AEC Computing and Applied Mathematics Center). Dec 1969. Contract AT(30-1)-1480. 39p. Dep. CFSTI.

Inertial range spectra of turbulent flows are deduced from the equations of motion. An explanation for the validity of universal equilibrium theories is provided. It is shown that Fourier-space cascades and physical-space intermittence are complementary aspects of the same reality. Spectra of the form $E(k) = Ak^{-\sigma}$ are found, where k is the wave number, A is independent of k, and $\sigma$ is a positive constant. $\sigma$ is evaluated; for the Burgers equation $\sigma = 2$; for the Navier-Stokes equations in both two and three space dimensions $\sigma = 2.3 \pm 0.15$. (auth)

**14156** (ORNL-TM-2802) COMPUTER CALCULATION OF TWO-DIMENSIONAL, STEADY-STATE HEAT TRANSFER IN CONCENTRIC CYLINDERS WITH INTERNAL HEAT GENERATION. Cristy, G. A. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 147p. Dep. CFSTI.

Thesis. Submitted to Univ. of Tennessee, Knoxville.

A computer program was developed for calculating steady state temperature distributions in concentric axisymmetric cylinders having internal heat generation. The program, written in Fortran IV, takes into account heat transfer by conduction, convection and radiation. The input format is simple and easy to use. Input consists of the dimensions of the cylinders and the thermal characteristics of the materials. The program divides the cylinders into nodes, arranges the connectors and calculates the temperature distribution in two dimensions. After calculating the temperature distribution in an array of nodes, the program subdivides the nodes and calculates the temperature distribution in the more detailed nodal system. The subdivision can be continued as long as desired provided the number of nodes does not exceed seventy-five (75) in either direction. The program provides an ability to calculate heat transfer by conduction and radiation across gas filled gaps within the cylinder, and to calculate the variation of the width of the gap due to thermal expansion. A program listing and instructions for assembly of input data are included. (auth)

**14157** (ORO-3936-2) THE VAPOR EXPLOSION: HEAT TRANSFER AND FRAGMENTATION. Technical Progress Report. Witte, L. C.; Cox, J. E. (Houston Univ., Tex. Dept. of Mechanical Engineering). Jan 1970. Contract AT(40-1)-3936. 17p. Dep. CFSTI.

Initial progress in an investigation of the interaction of hot, molten materials and liquids is reported. In studying the contributions of heat transfer and fragmentation to the overall phenomenon of explosive vapor formation the following four areas of interest were investigated: interaction of molten metal and liquids; transient heat transfer from small particles; stability of a molten jet; and the effect of pressure on vapor formation. Experimental and theoretical work in these four fields is reported. The results indicate that fragmentation is strongly dependent on the cooling characteristics of the quenching liquid. A technique for making vapor pressure calculations is described. A computer program for performing heat transfer calculations is being formulated. (L.C.L.)

**14158** (SC-CR-69-3162) STAGNATION LIQUID LAYER ABLATION OF SMALL SPHERES IN HYPERSONIC TRANSITION FLOW. Summary Report. Beal, J. L.; Brown, W. R.; King, S. R.; Tate, S. E. (Cornell Aeronautical Lab., Inc., Buffalo, N. Y.). May 1969. Contract 6005. 70p. Dep. CFSTI.

For Sandia Labs., Albuquerque, N. Mex.

This report is a summary of SC-CR-69-3080; SC-CR-69-3081.

Test materials were selected and equipment designed, fabricated, and assembled to study the melting ablation of small spheres in hypersonic transition flow over the Weber number range 1 to 10. The design concept called for the free suspension of test spheres in a vertical hypersonic stream through a balance between gravity and aerodynamic drag. However, due to lateral instability, all attempts to achieve stable suspension of the test spheres in the flow were unsuccessful. This lateral instability resulted from an undesirable radial distribution of test stream dynamic pressure. It was concluded that additional study and experimentation with nozzle design would be required in order to obtain the proper radial distribution of dynamic pressure in this low Reynolds number regime. (auth)

**14159** (SCL-DR-69-99) ONEDIM: A COMPUTER CODE FOR SOLVING ONE-DIMENSIONAL NONLINEAR HEAT TRANSFER PROBLEMS. Gabrielson, V. K.; Grange, B. W.; Christian, K. D. (Sandia Labs., Livermore, Calif.). Feb 1970. Contract AT(29-1)-789. 92p. Dep. CFSTI.

The computer code ONEDIM is used at Sandia Laboratories, Livermore, for solving transient and steady-state heat transfer problems of composite structures that can be modeled as slabs, cylinders, or spheres. Special features include variable material properties with phase changes plus radiation and convection options at the surface. Sources can be applied to any zone, and special options can be applied to internal gaps. Implicit integration with automatic time-step-control is used. Input is mnemonic, and flexible editing and plotting are available. (auth)

**14160** (WW-15-R-150) ON THE MASS- AND ENERGY EXCHANGE BETWEEN INTERACTING WATER-CHANNELS. van der Ros, T.; Bogaardt, M. (Technische Hogeschool, Eindhoven (Netherlands)). Jul 1969. 36p. Dep. CFSTI (U. S. Sales Only).

Single phase liquid mass and energy exchange experiments were carried out in a transparent test section presenting two adjacent channels with variable gapwidth and shape at atmospheric pressure and in a high pressure rig with a test section consisting of a four rod cluster at conditions close to average PWR operating conditions. In both test sections either one or two channels were electrically heated over a large part of the axial length and the amount of mixing was determined by measuring the amount of enthalpy increase in one channel. The ratio of the overall eddy diffusivity for heat ($\epsilon$) and the kinematic viscosity ($\nu$) has been determined as a function of the Reynolds number for different gapgeometries. Also radial temperature measurements have been conducted halfway the length of the transparent channels to measure rapid fluctuations as well as average conditions integrated over 1 sec. For visual observation, dye was injected into one channel and still and motion pictures were taken at different mass velocities. The results indicate that mixing in the described experiments occurred mainly in relative large "packages" that penetrated periodically from one channel into the other and vice versa in a wave like manner rather than on a microscopic turbulent scale. (auth)

**14161** STUDY OF DYNAMICS OF BUBBLE BOILING OF WATER ON FINE WIRES UNDER CONDITIONS OF FREE CONVECTION. Subbotin, V. I.; Kaznovskii, S. P.; Korotsev, S. K.; Sviridenko, V. E.; Selivanov, Yu. F. At. Energ. (USSR); 28: 9-13(Jan 1970). (In Russian).

A cinematographic study of the process of bubble boiling on fine wires under the conditions of free convection was carried out. Directions of escaping of bubbles from the surface of a heater were determined. On the basis of solving the equation of motion of a bubble and by a measurement of the distance passed by it in the direction opposite to that of the action of the lifting force, from the moment of escaping till full stop, the value of kinetic energy necessary for overcoming the gravitational forces is determined. The conclusion is made about a nongravitational nature of forces, causing escaping of a vapor bubble from the surface of a heater. Some hypotheses concerning the nature of these forces have been proposed. (auth)

**14162** HEAT TRANSFER IN TURBULENT FLOW WITH INTERNAL HEAT GENERATION IN CONCENTRIC ANNULUS. II. THERMAL ENTRANCE REGION. Michiyoshi, Itaru; Nakajima, Tsuyoshi (Kyoto Univ.). J. Nucl. Sci. Technol. (Tokyo); 7: 26-33(Jan 1970).

The results of a heat transfer analysis over the entire length of an annular passage for the thermal entrance region with turbulent flow in an annular space under conditions of uniform inter-

nal heat generation and uniform heat flux at the walls are presented. A graphical representation is given of the variations of Nusselt number at each wall surface with distance along the passage, and, subsequently, these fundamental solutions for uniform internal heat generation and uniform wall heat fluxes are applied to the case of arbitrary variations of internal heat generation and wall heat flux along the axial direction. (auth)

**14163** TEMPERATURE DISTRIBUTION IN GRAPHITE MATRIX HOLLOW FUEL COMPACTS. Oikawa, Takashi (Central Research Lab., Tokyo). J. Nucl. Sci. Technol. (Tokyo); 7: 41-50(Jan 1970).

With the view to gaining basic information to serve in reactor design and to permit better evaluation of fuel properties, the temperature distribution in graphite matrix hollow fuels containing Th is discussed on the basis of information obtained from equations expressing the temperature as a function of power density, fuel properties and cooling conditions. The relations found as a result among these factors indicate that high power density can be expected by adopting a combination of high thermal conductivity (>0.06 cal/cm · sec °C) optimized ratio between inner and outer diameters of hollow fuel (about 1 : 3), and high heat transfer coefficient of gap between fuel and sheath (by reducing the gap width to less than 0.2 mm). The temperature rise in the blanket is found to be insignificant. (auth)

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*Refer also to abstracts 13878, 14143, 14149, 14150, 14207, 14214, 14215, 14239, 14291, 14313, 14331, 14366, 14373, 14505–14507, 14702, 14727, and 14899.*

**14164** (AGN–8341) DESIGN DEFINITION AND SAFETY EVALUATION STUDY OF A COMPACT $^{60}$Co HEAT SOURCE IN SPACE. Final Report. Ruehle, William G. Jr. (Aerojet-General Corp., San Ramon, Calif. Nuclear Div.). Sep 1969. Contract AT(29-2)-2740. 194p. Dep. CFSTI.

This initial AEC safety study of a $^{60}$Co heat source in a space application considered the 30 kw(t) $^{60}$Co kernel with organic Rankine or Brayton conversion in a 1-year, manned, earth orbit flight. Safety aspects from fuel production to post-flight kernel disposal were evaluated. The results were very encouraging: no insurmountable safety problems were encountered. Further studies are necessary to define the best reentry package for the kernel and to measure molten soil, molten cobalt and seawater corrosion of tungsten. (auth)

**14165** (CEA-R–3902) ELECTROMIGRATION IN MOLTEN SALTS AND APPLICATION TO ISOTOPIC SEPARATION OF ALKALINE AND ALKALINE-EARTH ELEMENTS. Menes, Francis (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Nov 1969. 73p. (In French). Dep. CFSTI (U. S. Sales Only).

The separation of the isotopes of the alkaline earth elements was studied using counter-current electromigration in molten bromides. The conditions under which the cathode operates as a bromine electrode for the highest possible currents were examined. For the separation of calcium, it was necessary to use a stable $CaBr_2$–($CaBr_2$ + KBr) chain. In the case of barium and strontium, it was possible to use the pure bromides. Enrichment factors of the order of 10 for the 48 isotope of calcium and of the order of 1.5 for the rare isotopes of barium and strontium were obtained. The method is thus limited to yields of the order of a few grams. (auth)

**14166** (GA–8821) SNAP-15A THERMOELECTRIC GENERATOR. Summary Report, July 1, 1967–June 30, 1968. (Gulf General Atomic, Inc., San Diego, Calif.). 3 Sep 1968. Contract AT(04-3)-167. 60p. Dep. CFSTI.

The activities of the SNAP 15A fabrication and testing program for the period July 1967 through June 1968 are summarized. During this period the remaining ten upgraded generators were assembled and the environmental testing was initiated. It was discovered that the solder joint between the stainless steel output connector shell and the stainless steel container had developed leaks on generators 102 and 110. The mechanical test program was delayed to correct this potential reliability problem. The problem was traced to the subsequent welding of the fuel port cap adjacent to the solder joint during final fueling operations. This was solved by developing a technique for resoldering the assembled generators to strengthen the joint. Two of the generators (Nos. 101 and 111) developed leaks in the glass-to-metal seals of the electrical connector. A technique was then developed for sealing of these leaks with an epoxy material that cures at room temperatures. The mechanical testing was initiated on generators 103, 104, 105, and 106. During sinusoidal vibration tests generators 103 and 104 lost voltage output and did not recover. The type of response suggested that a resonance was occurring in the thermopile at low base frequencies of less than 100 cps. The mechanical testing of all generators was then discontinued. The other environmental tests were conducted without detrimental effect on the generator's performance. (auth)

**14167** (HIT–410) SPHERICAL CAPSULE TECHNOLOGY PROGRAM. PHASE III. SUMMARY REPORT. (Hittman Associates, Inc., Columbia, Md.). Jul 1969. Contract AT(29-2)-2475. 57p. Dep. CFSTI.

The analytical and experimental work performed with silver-silica composites in the development of a thermal switch for the Spherical Capsule Technology Program are described. The metal thermal switch concept is presented. Experimental materials and procedures are discussed. The impregnation technique and "thermal switch" heat treatment method are described. Tests performed to determine the compressive strength, electric resistivity, thermal conductivity, and compatibility of bare and impregnated foam are discussed. Analytical investigations were undertaken to develop heat source configurations using silver-silica composite technology. Both vented and non-vented spherical heat sources and a hemispherically-ended cylindrical heat source were investigated. A thermal model was developed and was used to determine the thermal response of the configurations to aerodynamic reentry heating. The experimental work successfully demonstrated the feasibility of the thermal switch concept at temperatures to about 1800°F using silica ceramic foam. Further analytical work is required to define the optimum heat source configurations in the power range of 650 thermal watts. (L.C.L.)

**14168** (ORNL-TM–2366) ISOTOPES KILOWATT PROGRAM. TASK I. CONCEPTUAL DESIGN AND EVALUATION. Robinson, R. A. (Oak Ridge National Lab., Tenn.). Jan 1970. Contract W-7405-eng-26. 333p. Dep. CFSTI.

Conceptual designs have been prepared for several types of radioisotope electric power systems in order to determine which types of systems show the most promise for early development for terrestrial and undersea applications in the 2 kW(e) to 10 kW(e) power range. Strontium-90 titanate and $^{60}$Co are considered as potential radioisotope fuels for the systems. The present development status of various energy conversion system components is reviewed. (auth)

**14169** (ORNL-TM–2876) RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR JANUARY 1970. Rupp, A. F. (Oak Ridge National Lab., Tenn.). Feb. 1970. Contract W-7405-eng-26. 24p. Dep. CFSTI.

Developments are reported for: neutron products; cyclotron products; fission products; radiation source development; radioisotope source safety testing; radioisotope applications development; radiation processing applications development; radioisotope sales; and radioisotope production. (J.C.W.)

**14170** (ORNL-tr–2273) RADIOACTIVE CERAMIC SOURCE OF CALCINED POLLUCITE. Olombel, Andre; Perebaskine, Cecile; Raggenbass, Andre. Translated by S. J. Rimshaw (Oak Ridge National Lab., Tenn.), from French Patent 1,478,339. 3p. Dep. CFSTI.

The development of a radioactive ceramic source with cesium-137 as the base in the form of calcined pollucite is described. The pollucite may be prepared by the wet method or by a dry method. The calcined pollucite is totally insoluble, and combines high mechanical resistance with high thermal resistance. The source may be used in an electric generator by use of a system of direct conversion from heat to electricity, applicable in a space vehicle. (J.C.W.)

**14171** (RLO–1750-54, pp 80-1) THE CONSERVATIVE NATURE OF $^{51}$Cr IN SEA WATER. Forster, William O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Data derived from measurements of $^{51}$Cr activities and water salinity taken between June 1965 and May 1966 in the Columbia River area are analyzed in an attempt to explain the behavior of $^{51}$Cr in seawater. (L.C.L.)

**14172** (SC-PR–69-881) AEROSPACE NUCLEAR SAFETY PROGRAM QUARTERLY REPORT, OCTOBER 1–DECEMBER 31, 1969. Illing, R. G. (comp.) (Sandia Labs., Albuquerque, N. Mex.). Jan 1970. 79p. Dep. CFSTI.

Impact tests were performed on five Transit design fuel capsules. Ten solid propellant burn tests have been conducted and data from nine tests are being compared to the theoretical thermal model, and agreement appears good. The thermal responses of the capsules in the Transit and Pioneer heat sources will be compared. Five heat source capsules were impact tested using the Sandia sled track facility and four capsules broke open. An anal-

ysis was conducted to determine the ablation which would occur during orbital decay and multiple orbit reentry of the isotopes hexagonal heat source. Molybdenum wires approximately 100 μm in dia were exposed to alpha particle doses simulating $^{238}PuO_2$ cermet fuels 1 to 5 years old. Room temperature tensile tests on wires exposed to 5-year simulants indicated that the ultimate strength increased by approximately 3% while the percent elongation was reduced about 40%. Two $ThO_2$ specimens were exposed to simulated reentry heat fluxes in the 40-kW arc tunnel for 30 sec. Neither specimen experienced any melt, ablation, or thermal fragmentation. (J.C.W.)

**14173** (SC-RR-69-820) TRANSIENT RESPONSE OF A PLASTICALLY ANISOTROPIC CYLINDER IN PLANE STRAIN. Duffey, T. A. (Sandia Labs., Albuquerque, N. Mex.). Dec 1969. 35p. Dep. CFSTI.

An anisotropic plastic analysis of a long cylinder subjected to internal impulsive pressure loading is presented. Transient response formulas are expressed in terms of elementary functions. The analysis is a generalization of earlier work for an isotropic plastic material. Comparisons between transient deflections for plastically anisotropic and isotropic materials indicate differences as large as 25 percent, even when uniaxial material properties are identical along principal directions in the cylinder reference surface. (auth)

**14174** USE OF RADIOISOTOPES IN BALL AND BEARING DEVELOPMENT. Salt, D. (Rolls-Royce Ltd., Derby, Eng.). Australas. Eng.; 49-51(Jul 1969).

In dynamic tests of bearings, the high radioactivity required for the detection of wear debris makes the parts unsuitable for building into standard gas turbine engines. However, severe wear occurs only during high bearing slip. Insertion of a radioactive ball or roller using less than 10 mCi of iron-59, or a radioactive seed, into the bearing cage allows measurement of the rotation speed of the cage and thus the calculation of slip. The use of a radioactive seed is preferred. Gamma radiation from cobalt-60 and iridium-192 is adequate. The instrumentation involves an external scintillation counter and ancillary circuits. Rotational speeds up to 18,000 rpm have been handled successfully. The system is being further modified. An example of the use of this radioisotope tachometer is given. (Australia)

**14175** ENERGY GENERATOR BASED ON $^{238}Pu$ FOR ELECTRICAL STIMULATION IN MEDICINE. Alais, M.; Berger, R.; Boucher, R.; Laurens, P. Bull. Inform. Sci. Tech. (Paris); No. 142, 31-8(Nov 1969). (In French).

The medical profession needs organ stimulators (particularly electrosystolic pacemakers) delivering electrical pulses, and for this a long-lived electrical source is necessary. It may be obtained by thermoelectric conversion of the energy supplied by plutonium-238 alpha radiation. The study and development of such stimulators are described. The sealed isotopic source is prepared by the C.E.A., the thermoelectric generator and the converter are manufactured by the ALCATEL Company and the Broussais hospital builds the prototype and performs the medical applications (experiments on animals then implantation in man). (auth)

**14176** LONG-LASTING THERMOELECTRIC GENERATORS. Alais, M. (Centre P. Hering, Bruyeres-le-Chatel, France); Artur, Y. Bull. Inform. Sci. Tech. (Paris); No. 142, 23-9(Nov 1969). (In French).

In many somewhat inaccessible places there is a need for very long-lasting sources of electrical energy. By the adaptation of thermoelements and long-lived radioactive sources, considered as heat sources, it is possible to produce more or less permanent electrical generators. The principles and development of thermoelectric generators are described with emphasis placed on the reliability aspect. The problems raised by the use of powerful radioactive sources are mentioned. Finally the generator GISETE 5, is described. (auth)

**14177** MARGUERITE ISOTOPIC GENERATORS FOR OCEAN SERVICE. Thery, P. (SNECMA, Suresnes, France); Chardin, P. Bull. Inform. Sci. Tech. (Paris); No. 142, 17-22(Nov 1969). (In French).

The study, manufacture and testing of a range of low- and medium-power isotopic generators known as MARGUERITE is discussed. Since February 1968, and without interruption, the first of these generators has been supplying a luminous buoy and an ultrasonic emitter in the Mediterranean. After a probation period in the Mediterranean, the 25 watt generator is at present under installation on an undersea petroleum well head in the Persian Gulf. This type of application is destined for considerable development in the years to come. (auth)

**14178** MANUFACTURE OF HEAT SOURCES FOR ISOTOPIC ELECTRICITY GENERATORS. Fradin, J. (CEN, Saclay, France). Bull. Inform. Sci. Tech. (Paris); No. 142, 7-16(Nov 1969). (In French).

Heat sources for isotopic generators have a high standard of efficiency since they can be used with complete safety under demanding conditions (temperature, corrosion). The Fission Product Service studies and manufactures such sources. Phases involved in this important work include: study of the radioactive compound and its preparation; study of the envelopes and casing conditions; study of the behavior of the unit under working conditions and of the compatibility between the different elements; and manufacture of the source. The Service has already loaded 5 isotopic generators of various designs, which represents the preparation of about 250,000 curies of strontium-90. (auth)

**14179** ELECTRICAL GENERATOR. (to Nuclear Materials and Equipment Corp.). British Patent 1,179,955. 4 Feb 1970. Priority date 2 Jun 1966, United States.

The design is given of a generator including an evacuated container, a heat source, a heat sink, thermoelectric apparatus in the container with a hot junction connected to the heat source and a cold junction connected to the heat sink. The heat-radiation reflecting device in the container confines the heat from the heat source to the hot junction and reflects the heat away from other components. The reflecting device is a gettering material and serves to maintain the vacuum at approximately $10^{-6}$ mm of Hg. The generator serves as approximately $10^{-6}$ mm of Hg. The generator serves as a power supply for a cardiac pacemaker. (J.C.W.)

**14180** ELECTRIC GENERATOR. (to Nuclear Materials and Equipment Corp.). British Patent 1,179,954. 4 Feb 1970. Priority date 2 Jun 1966, United States.

A design is given of a thermoelectric generator using a plutonium-238 heat source, applicable to cardiac pacemakers. Plutonium-238 develops heat which serves as the hot-junction for a thermoelectric converter which is constructed to deliver adequate voltage. The heat source is enclosed in a radiation-heat shield which prevents the radiation of heat from the source to the thermoelectric elements and to the walls of the container. (J.C.W.)

**14181** ON THE INTENSIFICATION OF UNDEREXPOSED RADIOAUTOGRAPHS BY TRAPPING OF RADIONUCLIDES. Hermann, W.; Schumpelt, W.; Treutler, H. Chr. (Institut fuer Angewandte Radioaktivitaet, Leipzig). Isotopenpraxis; 5: 356-61 (Sep-Oct 1969). (In German).

Foundations and the practical execution of a technique to intensify density distributions of underexposed radioautographs are described. Trapping of radionuclides on its silver grains and following radioautography make possible intensification factors of more than 100 and allow an essential shortening of exposure time and rationalization of evaluation in such cases when the detail losses connected with this are not excessive. The results of measurements and examples of corresponding radioautographs are given. (auth)

**14182** THE EVOLUTION OF ISOTOPIC AND RADIATION TECHNIQUE IN THE GDR. Uhlig, K. (Ministerium fuer Grundstoffindustrie, Berlin). Isotopenpraxis; 5: 313-19(Sep-Oct(1969). (In German).

The evolution of isotopic and radiation techniques in the GDR and the evolution of international cooperation of the GDR with the socialist countries in the field of isotopic and radiation techniques are discussed. Isotope production for 1958 through 1968 is reported. Uses of radioisotopes and radiation sources are reviewed. (M.C.G.)

**14183** VACUUM TECHNOLOGY ASPECTS IN THE DESIGN OF ELECTROMAGNETIC ISOTOPE SEPARATORS. Chavet, I. (Soreq Nuclear Research Centre, Yavne, Israel). Vacuum; 19: 547-52(Dec 1969).

The essential information required for the design of an effective vacuum chamber and vacuum system to be used in an electromagnetic isotope separator assembly, is presented. The effects of residual pressure on isotopic contamination and on beam oscillations are discussed. Methods for calculation of the pumping requirement and representative pumping equipment are described. (auth) (UK)

**14184** RADIOACTIVE HEAT SOURCE SUITABLE FOR USE IN A CARDIAC PACEMAKER. Barthelemy, Pierre; Boucher, Rene (to Commissariat a l'Energie Atomique). British Patent 1,180,360. 4 Feb 1970. Priority date 9 Nov 1967, France.

A design is given of a cardiac pacemaker consisting of a heat source comprising a leak-tight container and an $\alpha$-emitting material consisting of an alloy of $^{238}Pu$ containing less than 1 ppM of $^{236}Pu$ and an addition of americium, cerium, gallium, indium, or scandium. The alloying addition allows the alloy to remain in delta

phase and retain a face-centered crystal structure between normal atmospheric temperature and 450°C. (J.C.W.)

**14185** EXAMPLES OF THE ECONOMIC IMPORTANCE OF WEAR STUDIES BY USING RADIOACTIVE NUCLIDES. Polzer, G. (Karl-Marx Univ., Leipzig). Isotopenpraxis; 5: 383-4(Sep-Oct 1969). (In German).

The economic savings in time, money, and material which resulted from the use of radioactive tracer methods for investigating wear losses in the manufacture of special steels and in the operation of rotary machinery are discussed briefly. The importance of such radioactive methods to further research on friction, lubrication, and wear is emphasized. (L.C.L.)

**14186** HIGH INTEGRITY BETA RADIATION SOURCES. Case, F. N.; Mackey, T. S. (Oak Ridge National Lab., Tenn.). pp 633-42 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Beta sources used for process irradiation must be designed to balance the desire for high efficiency of utilization of the emitted beta radiation and the requirements for integrity. The ORNL beta source development program has been aimed at the design of thin-walled source capsules that can be fabricated at low cost and the development of source forms that are highly resistant to powdering and dissolution. The program includes the development of methods for preparing various chemical compounds of strontium and processing these compounds into physical forms that can be economically encapsulated, the development of encapsulation methods, and the determination of source characteristics which are pertinent in operational safety. Beta output from capsules loaded with ~39 Ci per inch of capsule, in the form of a slab 0.085 in. thick and 0.375 in. wide covered with 0.006 in. stainless steel, is approximately 30% of the beta particles emitted from the $^{90}Sr$ in the source form. The dose rate at the surface is $2.1 \times 10^7$ rad/h. (auth)

**14187** $^{99m}Tc$ POINT SOURCE FOR TRANSMISSION SCANNING. Sorenson, J. A.; Briggs, R. C.; Cameron, J. R. (Univ. of Wisconsin, Madison). J. Nucl. Med.; 10: 52-3(May 1969).

The preparation of metastable technetium-99 point gamma sources for transmission imaging in rectilinear scanning is described. Also, the performance of this point gamma source for transmission scanning is discussed. (W.H.K.)

**14188** RADIOISOTOPE-CONTAINING MICROSPHERES. Ashby, George E.; Mac Cragh, Adolfo; Smith, Jean G. (to W. R. Grace and Co.). U. S. Patent 3,493,514. 3 Feb 1970. Filed 20 Jun 1967.

A process for preparing radiation sources in a form that can be easily handled and can be prepared with a minimum of risk by impregnating a base with the desired quantity of the radioisotope material is given. The base may be inert or it may be a material that reacts with the radioactive ion to form a compound. (Offic. Gaz.)

**14189** FUTURE OWNERSHIP OF THE AEC'S GASEOUS DIFFUSION PLANTS. HEARINGS BEFORE THE JOINT COMMITTEE ON ATOMIC ENERGY, CONGRESS OF THE UNITED STATES, NINETY-FIRST CONGRESS, FIRST SESSION, JULY 8, 9, AND AUGUST 5, 7, AND 8, 1969. Washington, D. C.; Joint Committee on Atomic Energy (1969). 602p. GPO 2.50.

**14190** NONSHIFTING RADIATION SOURCE CAPSULE. Dukes, John R. (to Industrial Nucleonics Corp.). U. S. Patent 3,488,502. 6 Jan 1970. Filed 2 Jun 1966.

A substantially immobile nonshifting relatively high energy radiation source includes a particulate radioisotope-bearing material positioned within a chamber formed in a capsule. Movement of the radioactive isotope element or any attenuating mass is prevented by a deformable conformational barrier member which is nonporous relative to the particulate material and which prevents any attenuating producing movement of any particulate material within the capsule. In the case of gas producing radioisotopes, provision is made to permit escape of gas while preventing movement of attenuating masses or radioactive isotope material. Various radioisotopes and barrier members are described as well as various ways to assemble a nonshifting source. (Offic. Gaz.)

**14191** RECOVERY OF FADED PHOTOGRAPHS BY NUCLEAR TECHNIQUES. Chatters, R. M.; Jacobs, Camille (Washington State Univ., Pullman). Photogr. Appl. Sci. Technol.; 4: 26-7; 47(Jan 1970).

Studies on the recovery of faded photographs, old stereoptican views, glass plate negatives, and tintypes are described. Previous experiments of recovery by chemical treatment, direct photography, direct treatment with radioactive solutions, and a method by Ostroff whereby neutrons from a reactor were employed to produce radioactive silver in photographic images and autoradiographs made from the activated photographs are described. The present method varies from the method by Ostroff in that the length of irradiation and exposure times differ. Photographs were exposed for 15 minutes at $10^{13}n/cm^2/sec$. This was followed by storage of the hot photographs for up to 7 days and exposure of the film to the irradiated photographs for 24 hours. The most satisfactory film was found to be Kodak Industrial X-Ray Type M. In the present method, silver-108 was allowed to completely decay and silver-110, half-life of 260 days, was utilized. The delayed procedure also eliminated the short half-life radioisotopic forms of chlorine, bromine, and iodine. (J.C.W.)

**14192** ISOTOPES AND RADIATION TECHNOLOGY. VOLUME 7, NUMBER 2. Baker, P. S.; Lafferty, Robert H. Jr.; Gerrard, Martha; Greene, R. E.; McKinney, F. E.; Miller, F. J.; Hess, D. N. (eds.). One of Four Quarterly Technical Progress Reviews Published for the Division of Technical Information, USAEC. Oak Ridge, Tenn.; Oak Ridge National Lab. (Winter 1969–70). 116p. GPO $0.70.

Separate abstracts were prepared for each of eleven papers in Section I. Sections II and III contain miscellaneous information on the uses of radioisotopes in France, Germany, and Sweden; USAEC activities; and publications of the ORNL Isotopes Information Center for which no abstracts were prepared. (L.C.L.)

*For abstracts of individual papers see: 14193–14200 and 14505–14507.*

**14193** DEVELOPMENT OF A SIMPLIFIED STIRLING ENGINE TO POWER CIRCULATORY-ASSIST DEVICES. Martini, W. R.; Johnston, R. P.; Goranson, R. B.; White, M. A. (Donald W. Douglas Labs., Richland, Wash.). Isotop. Radiat. Technol., 7: 145-60(Winter 1969–70).

The scope and present status of a research program at the Donald W. Douglas Laboratories to develop a Stirling engine power source for circulatory-support devices are presented. A simplified version of the Stirling engine, which can produce the required power output to drive a heart pump with high efficiency and reliability, is described. The predicted performance characteristics of the simplified Stirling and a conventional Stirling engine are compared. The design is presented, and the results of a design analysis are discussed briefly. The status of an experimental program is reported. Basic design requirements are described along with presently achieved and projected performances for the laboratory prototypes. The major problems are outlined, and possible methods of solution are discussed. (auth)

**14194** A RADIOISOTOPE-POWERED STIRLING ENGINE FOR CIRCULATORY SUPPORT. Buck, K. E.; Forrest, D. L.; Tamai, H. W. (Aerojet-General Corp., San Ramon, Calif.). Isotop. Radiat. Technol., 7: 161-71(Winter 1969–70).

Aerojet-General has recently completed a conceptual design study of a radioisotope power source suitable for implantation in the human body. The output power from the device is to be used for circulatory support, either to assist a damaged heart or to drive an artificial heart. The design criterions are discussed in detail for a linear Stirling engine device. The compressor portion of the engine was tested, and its performance characteristics under experimental conditions are reported. (auth)

**14195** DESIGN OF AN IMPLANTABLE, RANKINE-CYCLE RADIOISOTOPE POWER SOURCE. Huffman, F. N.; Harvey, R. J.; Kitrilakis, S. S. (Thermo Electron Corp., Waltham, Mass.). Isotop. Radiat. Technol., 7: 171-81(Winter 1969–70).

An implantable power source, fueled with a radioisotope and using a miniature Rankine-cycle steam engine, was designed to drive a circulatory-support system. The power-source design is based on parametric studies, system requirements, and experience in developing steam-engine power supplies. By coupling this 4-watt (mean hydraulic output) power source to circulatory-system-assist devices, a useful, implantable circulatory-support system is possible because of the efficiency (20%), size (1 liter), mass (2 kg), and high reliability. (auth)

**14196** IMPLANTABLE ARTIFICIAL-HEART POWER SOURCE. Lance, J. R. (KPA Nuclear, Inc., Large, Pa.); Selz, A. Isotop. Radiat. Technol., 7: 182-92(Winter 1969–70).

The conceptual design of an implantable radioisotope power source for artificial-heart applications is described. The energy converter used is a novel rotary expansion steam engine that converts the decay heat of $^{238}Pu$ to hydraulic power. A complete artificial-heart system would use the regulated hydraulic output to drive a biventricular blood pump. The power-source design meets currently defined physiologic constraints and requirements imposed by implantation within the human body. Six watts of peak-

blood pumping power is provided by the power source and is sufficient to extensively rehabilitate the average user. Total implantation of the power source frees the user from dependence on external power supplies and eliminates the problems associated with percutaneous leads. The design study indicates that only a modest extension of proved technology, without the necessity of engineering breakthroughs, is required to fully develop the described implantable power source. (auth)

**14197** RADIOISOTOPE-POWERED CARDIAC PACEMAKER. Isotop. Radiat. Technol., 7: 192-3(Winter 1969–70).

The design and operation of an implantable 97 g cardiac pacemaker powered by a small $^{238}Pu$ source are described. In June 1969, one of these units was successfully implanted in a dog at the National Health Institute, and there are plans for similar implantations in the near future. (L.C.L.)

**14198** BRITISH RADIOISOTOPE-POWERED CARDIAC PACEMAKER. Isotop. Radiat. Technol., 7: 194-6(Winter 1969–70).

The British demonstration model of a battery powered with a long-lived radioisotope—$^{238}Pu$—has operated since June 7, 1968, with a dc–dc converter to drive a cardiac pacemaker. The battery is being developed at the British Atomic Energy Research Establishment (AERE), Harwell, and the commercially designed pacemaker circuit was constructed at the Atomic Weapons Research Establishment, Aldermaston. Tests are being made with the unit for the Department of Health and Social Security to determine the long-term reliability of implantable radioisotope-powered cardiac pacemakers. Possible improvements in the protection of the electronics by encapsulation are also being investigated, with the idea of eventual implantation, and plans for future development include studies aimed at decreasing the $^{238}Pu$ inventory and ensuring that the lifetime of more than 10 yrs can be guaranteed. (auth)

**14199** PROMETHIUM TECHNOLOGY: A REVIEW. Fuliam, H. T.; Van Tuyl, H. H. (Battelle-Northwest, Richland, Wash.). Isotop. Radiat. Technol., 7: 207-21(Winter 1969–70).

The technology that has been developed for using promethium as lightly shielded heat and radiation sources is described. A summary of available information is given about applications, nuclear properties, production in USAEC and commercial power reactors, chemical purification, chemical and physical properties of candidate fuel forms, compatibility, and source-fabrication technology. (auth)

**14200** STUDY OF $^{171}Tm$ AS POWER SOURCE FOR CIRCULATORY-SUPPORT SYSTEM. Poggenburg, J. K. (Oak Ridge National Lab., Tenn.). Isotop. Radiat. Technol., 7: 222-31(Winter 1969–70).

A study of production methods for and properties of $^{171}Tm$ indicated that the limited production capacities and extremely high estimated cost—more than $30 thousand per watt—make it impracticable as a power source for a circulatory-support system. The technical and economic factors were considered for targets of natural erbium, enriched $^{170}Er$, and natural thulium. (auth)

## Materials Testing

*Refer also to abstracts 14173, 14181, 14674, and 14769.*

**14201** A STATISTICAL THEORY OF DESIGN FOR PLATING THICKNESS MEASUREMENTS BY RADIATION BACKSCATTER METHODS. Fox, Jerry D.; Taylor, Grover M. (Univ. of California, Livermore). Mater. Eval.; 28: 17-24(Jan. 1970).

The application of statistical experimental design techniques to two methods of plating thickness measurements, x-ray, fluorescence and beta-radiation backscatter is described. The following factors are discussed: number of standards, accuracy of standards, thickness range and accuracy of radiation measurements for both the standard and the unknown thicknesses. A least-means-squares technique is applied for fitting the calibration curves, and analytical techniques are used to study the effect of variations in the above factors on the final uncertainty in determination of the unknown thicknesses. Tabulated experimental and theoretical data are included for guidance in designing nondestructive testing programs that use these techniques. (auth)

**14202** 1969 BOOK OF ASTM STANDARDS, WITH RELATED MATERIAL. PART 7, NONFERROUS METALS AND ALLOYS (INCLUDING CORROSION TESTS); ELECTRODEPOSITED METAL LIC COATINGS; METAL POWDERS; NONFERROUS FILLER METAL; NONFERROUS SURGICAL IMPLANTS. Philadelphia; American Society for Testing and Materials (1969). 1115p. $20.00.

The volume is one of 32 and contains formally approved ASTM standards, tentative specifications, methods of testing, recommended practices, definitions, proposed methods, and related materials. (J.R.D.)

**14203** INSPECTION OF THE JPDR PRESSURE VESSEL BY THE ELECTRIC-RESISTANCE TECHNIQUE. Yamaguchi, Tomio (Mitsubishi Heavy Industries, Ltd., Kobe, Japan); Fujimura, Tsutomu. Hihakai Kensa; 18: 298-306(Jul 1969). (In Japanese).

In the nondestructive testing of metallic materials by electric resistance technique for thickness measurement and defect detection, the electric potential difference at the position of test is utilized to find the dimension of a defect. Basic experiments and simulation tests for the JPDR pressure vessel were carried out. Later the actual inspection of the JPDR pressure vessel by the electric resistance technique was carried out. In the inspection, the nozzle position for forced coolant circulation and the bottom of the pressure vessel were searched for defects, and fair success was obtained. Features of the electric resistance method employed are the remote operation in inspection, the inspection of clad steel, the utilization of potential difference between the contact elements for defect detection, and particular emphasis put on the potential difference distribution. (NSA of Japan)

**14204** MODERN INSPECTION METHODS FOR IMPROVING THE QUALITY OF CASTINGS. Boltik, Vladimir; Fait, Zdenek. Skoda Rev.; No. 3, 58-61(1969).

The nondestructive testing methods used at the Skoda Works (Czechoslovakia) for determining the quality of large castings, such as pump and turbine casing sections, are described. These methods include irradiation by betatron for the inspection of the internal quality of castings with wall thicknesses up to 350 mm; x-ray inspection, ultrasonic inspection for determining the size of internal defects, and an electromagnetic method for revealing surface defects. The importance of all these methods and combinations thereof to the verification of material quality in large castings is emphasized. (L.C.L.)

**14205** BETATRON RADIOGRAPHIC TECHNIQUES FOR TITANIUM BILLETS. Cattler, F. J. (TRW, Inc., Cleveland). Contract F33615-67-C-1697. Mater. Eval.; 28: No. 2, 37-42 (Feb 1970).

A program to develop and improve nondestructive testing techniques for titanium billets included an investigation of betatron radiographic techniques. Various lead screen, film, and geometry combinations were evaluated on 17-in.-diameter billets. Standard radiographic penetrameters were used for evaluating the radiographic procedures. This inspection method was capable of resolving a 40 thousandths-in.-diameter by 40 thousandths-in.-deep hole (1T-2.0 penetrameter) through 17 in. of titanium on a Class II x-ray film. Various data are shown which illustrate the effects of back and front lead screen thickness on exposure and resolution. (auth)

**14206** NONDESTRUCTIVE TESTING OF SMALL METAL TUBING. Poole, Harry W. (Superior Tube Co., Norristown, Pa.). Mater. Eval.; 28: No. 2, 40A-6A(Feb 1970).

Nondestructive testing methods which have made it possible to inspect to higher standards and also contribute to the solution of the manufacturing problems created by these standards are described. Methods of manufacturing tubing to meet present standards are outlined. The steps include greater raw material selectivity, better material conditioning, plug drawing, use of protective atmospheres, use of polishing for surfaces, controlled pickling and exacting handling care. Descriptions of nondestructive test methods are included. (J.R.D.)

**14207** PROCEEDINGS OF THE SEVENTH SYMPOSIUM ON NONDESTRUCTIVE EVALUATION OF COMPONENTS AND MATERIALS IN AEROSPACE, WEAPONS SYSTEMS, AND NUCLEAR APPLICATIONS, April 23–25, 1969, SAN ANTONIO, TEXAS. North Hollywood, Calif.; Western Periodicals Company (1969). 453p. (CONF-690437).

Forty-five papers were presented at the conference. A separate abstract was prepared for each of nineteen papers. The remaining papers include information on the uses of photoelasticity and ultrasonic techniques in the study of crack propagation, various nondestructive testing techniques, a simplified helium camera for contact microradiography, mechanical impedance alogrithm analysis of taper-lok bolted joints, and the magnetic tape recording of ultrasonic test information. (J.G.B.)

*For abstracts of individual papers see: 13795, 14208–14223, 14769, and 14770.*

**14208** RESEARCH, DEVELOPMENT, AND APPLICATIONS AT THE BRITISH NONDESTRUCTIVE TESTING CENTRE.

Sharpe, Roy S. (Atomic Energy Research Establishment, Harwell, Eng.). pp 37-42 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

A center for research and development to assist industry in solving materials inspection problems was set up by the British Ministry of Technology at the Atomic Energy Research Establishment, Harwell. The center is expected to demonstrate industrial interest and commercial viability by attracting and carrying out sponsored work in all areas of nondestructive testing, to complement what is already available in Britain from the organized structure of the NDT industry and the industrial Research Associations. In addition to sponsored work, the center initiates research and development in areas where there is a commercial or a national interest justification and the program of work in this category is regularly reviewed by an Advisory Committee of specialists. The center has also set up an advisory service for NDT which collects and disseminates information on all aspects of the subject. The paper describes how the center has grown from a development section originally devoted to the requirements of the British nuclear power program and discusses how the current programs of work have evolved naturally from this earlier rather specialized expertise. (auth)

**14209** RADIOACTIVE GAS PENETRANT INSPECTIONS. Eddy, William C. Jr. (Industrial Nucleonics Corp., Columbus, Ohio). pp 58-66 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

The detection and display of microscopic defects in material surfaces using diffused radioactive krypton-85 as a gaseous penetrant are discussed. The gaseous penetrant because of its extremely small-sized atom allowed penetration into cracks and surface conditions which were not being detected presently by using the the more conventional dye penetrant techniques. This program began in an evaluation of the release of the radioactive gas as a function of work input to the material. Its sensitivity to microscopic flaws was noticed in this work and was continued and explored separately from the fatigue studies. The technique was applied to a number of practical aerospace problems. It showed great sensitivity in detecting anodized flaws, bearing porosity, and turbine blade cracks in actual service hardware, which previously were pronounced sound by the best existing techniques. The widespread application of this technique is limited at present by the need for radioactive gas-handling facilities and the present long-exposure periods required to make autoradiographs. The material can be treated in such a manner that it can be returned to service without radioactive contamination. Work leading to one-second electronic imaging and automated gas handling appears promising and may clear the way for more widespread application of the system in typical overhaul facilities. (auth)

**14210** ACOUSTIC EMISSION: A NEW TOOL FOR EVALUATING STRUCTURAL SOUNDNESS. Hutton, Philip H. (Battelle-Northwest, Richland, Wash.). pp 165-79 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969). (BNWL-SA-2449).

See CONF-690437.

Acoustic emission is defined as the elastic waves produced in a solid material by energy released as the material is deformed or fractured. These waves can be detected at the surface of the material with high sensitivity transducers. This provided the basis for a new technique for monitoring metal structures, pipes, pressure vessels, graphite shapes, etc., to detect structural deterioration before failure occurred. Flaw detection resolution using acoustic emission exceeds that of any of the conventional nondestructive techniques such as ultrasonics, radiography, etc. It is, however, limited to detection of an active strain or flaw area—it will not detect static flaws. Development work to apply acoustic emission to detect flaw growth in nuclear reactor pressure systems is discussed. It also deals with applications of acoustic emission to detect formation of cracks in welds, metal fatigue, and use as a surveillance tool in studying pressure vessel fracture modes. Preliminary work on application to graphite is included. (auth)

**14211** NON-DESTRUCTIVE TESTING APPLIED TO NUCLEAR VESSEL FABRICATION. Proctor, E. S. (Combustion Engineering, Inc., Chattanooga). pp 180-7 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

During the fabrication of a nuclear pressure vessel, approximately 2,000 nondestructive examinations were performed on materials and/or fabrication processes. These tests included radiography, ultrasonic examination, dye penetrant, magnetic particle, eddy current, and leak detection. The assurance of the component quality depended largely on the adequacy of nondestructive testing equipment and procedures, and the qualification of personnel conducting the examination. Nondestructive examination of materials prior to use in fabrication, and of the fabrication processes must, in many cases, be evaluated to standards more stringent than required by specifications. The use of timely testing and rigid construction standards resulted in the reduction of rework costs and delays. This paper discusses the application of the tests, problems, and limitations encountered, and the assurance of the final quality through nondestructive examinations. (auth)

**14212** NONDESTRUCTIVE INSPECTION OF NUCLEAR POWER PRESSURE BOUNDARIES. Whiting, A. R.; Lautzenheiser, C. E. (Southwest Research Inst., San Antonio). pp 188-93 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

Current design changes in nuclear power pressure boundaries to allow access for inspection of critical regions resulted from requirements to ensure continued safety and minimize system downtime. These design changes and the application of nondestructive inspection methods and equipment to determine the initial and continued integrity of nuclear power pressure boundaries are discussed. Techniques used to obtain pre-service fingerprint data and the data acquisition instrumentation necessary to correlate this information with subsequent in-service inspection are reviewed. (auth)

**14213** EVALUATION OF DISCONTINUITIES IN HSST TWELVE INCH-THICK PLATE. Klindt, K. K.; Canonico, D. A. (Oak Ridge National Lab., Tenn.). pp 194-209 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

The Heavy Section Steel Technology Program (HSST) provided an opportunity to correlate nondestructive testing techniques with a destructive investigation. A major task was the characterization of a number of 12-in.-thick plates of ASTM A533 grade B steel. This obligation provided the opportunity of following the processing of the steel from melting through rolling and final heat treatment. Included in this responsibility was the nondestructive testing of the plates. During the ultrasonic testing of HSST Plate 01, a number of large indications were found. These areas were cut out of the plate, and an extensive nondestructive testing study was conducted. In mapping out the discontinuities, the testing procedure was varied to include the effect of ultrasonic transducer size, testing frequency, and amplifier gain. This was done when the plate was in a full 12-in. thickness and again after the center 4 in. (which was shown to contain all of the indications) was removed. A map of the percent back reflection loss was made for each combination of the testing parameters. The test frequency had the major effect on the size of the area defining the complete loss of back reflection. Radiography and magnetic particle inspection of cut surfaces revealed extensive discontinuity areas. After the ultrasonic studies, the specimen was sectioned to expose its interior, and an extensive destructive investigation was conducted. The area contained many lamellar type voids filled with foreign inclusions. This foreign material occurred in platelike form, aligned in the rolling direction, with a thickness of as great as $\frac{1}{8}$ inch. It was identified as being rich in Si, Mn, Al, and Fe. Microstructural studies were conducted in the area of the discontinuities and the surrounding base metal was analyzed with an electron beam microprobe. (auth)

**14214** REMOTE ULTRASONIC EXAMINATION OF CLOSURE WELDS ON ISOTOPE CAPSULES. Cook, K. V. (Oak Ridge National Lab., Tenn.). pp 210-18 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications,

April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

The nondestructive inspection of closure welds on fueled isotope capsules was necessary to ensure high integrity and thus prevent the release of toxic radioactive fuels. Closure or seal welds were inspected with an ultrasonic pulse-echo technique. This test was performed remotely in a hot cell and was used on seven strontium-fueled capsules sealed by electron beam welding. The equipment is discussed along with results of calibration and correlation studies performed before and after hot cell evaluation. Discontinuities as small as 0.015 in. in diameter were detected and recorded. Weld penetration can be determined to an accuracy of 0.010 in. from the x-y recordings. (auth)

**14215** THE NONDESTRUCTIVE TESTING OF WELDS IN HAYNES ALLOY NO. 25 IN SNAP-27 ISOTOPIC HEAT SOURCE CAPSULES. Barnett, A. G.; Gray, M. I.; Tucker, P. A. (Monsanto Research Corp., Miamisburg, Ohio). Contract AT(33-1)-GEN-53. pp 219-25 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

Radiography and ultrasonics were performed on the outside closure welds in Haynes alloy No. 25 in the SNAP-27 isotopic heat sources. The SNAP-27 radioisotope fuel capsule is the energy producing component for a thermoelectric generator which produces a thermal power of 1480 W. The capsule is cylindrical with an outside diameter of approximately 2.5 in. and offers radiation levels in the order of 2 R/hr at a distance of 20 cm from the axis of the container. T.I.G. welds were used in a 40 to 20 mil step joint with a step length of 60 mils. Since the radioisotopic heat source contained large amounts of high Z material, $^{192}Ir$ was used exclusively in tangential radiography which required 16 exposures for each capsule covering approximately 22.5 degrees of the specimen per radiograph. The ultrasonics employed a short focused transducer operating at 21 degrees to the radius vector of the cylinder and in a plane perpendicular to the plane containing the weld line. The equipment and techniques employed in the ultrasonics were developed by Battelle–Northwest. Extensive metallography was performed in the weld development prior to actual capsule welding and also in example welds required at the time of production. In addition, one finished capsule was destructively examined during production to correlate suspicious nondestructive indications. The results of these nondestructive methods are discussed and evaluated in terms of the destructive metallography. (auth)

**14216** PERIODIC INSPECTION PLAN FOR THE OSKARSHAMNSVERKET REACTOR PRESSURE VESSEL. Lautzenheiser, C. E. (Southwest Research Inst., San Antonio); Sandberg, Olle. pp 282-90 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

The Oskarshamnsverket is a boiling-water system operating at 70 bars pressure and with an output of 440 MW. The system was designed and constructed on a turnkey basis. Early in the design phases, efforts to formulate a periodic inspection program were initiated. This program was based on the design analysis and utilized ultrasonic information generated during fabrication of the vessel. The final plan incorporated changes and modifications due to access, ultrasonic inspection performed during manufacture, and experience of the utility and the inspection agency, Tekniska Rontgencentralen. The inspection plan is primarily based on the use of ultrasonic techniques using mechanical scanning equipment. The conceptual design of this equipment and the design philosophy are discussed. (auth)

**14217** REMOTE ULTRASONIC TESTS IN PRESSURE VESSELS OF OPERATING NUCLEAR POWER STATIONS. Gasparini, R. (Ente Nazionale per l'Energia Elettrica, Rome). pp 298-305 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

The inaccessibility of existing reactor pressure vessels from the outside made it necessary to design special equipment for periodic remote inspections under water of important areas such as nozzles. The equipment using the so-called immersion method, optimized to detect the presence of cracks starting from the inner surfaces is described. Information is given on the experience acquired from the inspections performed during refueling shutdowns of two water reactor power stations (BWR and PWR) since 1967. A description is provided of the laboratory tests for calibration of the equipment used for the determination of possible defects and of the interference by crud deposits on the inner surfaces. (auth)

**14218** THE STATE-OF-THE-ART OF NONDESTRUCTIVE EVALUATION IN CONCRETE TECHNOLOGY. Li, Shu-tien; Russell, James E. (South Dakota School of Mines and Tech., Rapid City). pp 306-14 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

High-quality, high-strength concrete is an indispensable material in launching pads of the present and in spaceports of the future, in military air fields and in hardened missile bases, in nuclear reactor pressure vessels, and in their containment structures. The nondestructive inspection, characterization, and evaluation of concrete in situ, and concrete structures have become the engineers' most economical, least time-consuming, and most readily applicable methods. Herein are accounted for the state-of-the-art of these tests in contemporary concrete technology: mechanical means including spring hammer, Schmidt spring hammer, pendulum hammer, and indentation; electrical resistance meters; gamma-ray and neutron tests; radiography and covermeter; sonic measurements of the fundamental or resonant frequency of vibration, and pulse methods for measuring the propagation of sound vibrations of ultrasonic frequency. They are first presented as being applied to nondestructive evaluation of concrete and concreting materials. But finally applications of some of these nondestructive techniques are extended to other areas of materials technology and geotechnology. (auth)

**14219** GAMMA RAY WELD INSPECTION SYSTEM. Payne, D. M. Jr. (Atomics International, Canoga Park, Calif.). pp 315-19 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

A three gamma ray beam technique was used to inspect an opposed arc weld for weld nugget penetration in an aluminum-copper alloy. The system compared the difference between gamma ray attenuation through the center of the weld with that through the sides of the weld. Weld center attenuation was greater due to concentration of copper in this region. The amount of copper concentration increased with weld nugget overlap. An averaging circuit was used to reduce the variation due to counting statistics. A profile of weld nugget penetration was detected and recorded. (auth)

**14220** AN X-RAY TECHNIQUE FOR MEASURING THICKNESS OF TUNGSTEN ON COPPER. Foster, B. E.; Snyder, S. D. (Oak Ridge National Lab., Tenn.). pp 337-42 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

An x-ray attenuation technique was developed to measure the thickness of vapor-deposited tungsten on the inside wall of copper tubing. The radiation source was a Norelco MG-150 x-ray unit operated at 150 kVcp and 3 mA with copper filtration to reduce the overall beam intensity and absorb the low-energy x rays. Narrow beam collimation was directed radially into the duplex tube. The detector, placed in the bore of the tube, consisted of a NaI(Tl) crystal optically coupled to a commercial fiber optics bundle. The bundle was, in turn, optically coupled to a photomultiplier tube. The output signal from the photomultiplier was monitored by a digital voltmeter. The detector was held stationary in the beam and positioned for maximum signal. The tube to be measured was translated with the detector remaining on the axial center of the tube. Measurements were made at specified circumferential and longitudinal positions. Our calibration curve was obtained by plotting the voltmeter reading versus the thickness of rolled tungsten sheet specimens. As the x rays passed through the duplex wall, the tungsten attenuation had the greatest effect per unit of thickness, thus minimizing the effect of any variations in copper wall thickness. A copper thickness change of 0.005 in. was equivalent to a 0.0005-in. tungsten thickness and produced that tolerance on the final thickness determinations. (auth)

**14221** NONDESTRUCTIVE STRESS MEASUREMENT BY X-RAYS. Montgomery, Robert L. (Boeing Co., Wichita, Kan.).

pp 343-53 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

X-ray stress analysis equipment and techniques are described. Special equipment includes a portable stand which can accurately position an x-ray camera and tube with respect to a large specimen, and a gage which can measure the distance and position of the camera relative to the specimen. Special techniques include the use of the centroid of a diffraction line as a measure of the diffraction angle. Corrections to experimental centroids for diffractometer aberrations were derived. Some problems encountered in the measurements and interpretation are discussed. Correlation of x-ray stress results with service performance in some cases is briefly described. (auth)

**14222** DEVELOPMENT AND POTENTIAL UTILIZATION OF A NEUTRON RADIOGRAPHY FACILITY AT THE UNIVERSITY OF TEXAS NUCLEAR REACTOR LABORATORY. Bouchey, G. D.; Gage, S. J. (Univ. of Texas, Austin). pp 354-62 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

Radiography using neutrons from a nuclear reactor has certain advantages for many applications in the area of nondestructive testing over the familiar x-ray or gamma radiography. Among the more important advantages of neutron radiography are the ability to examine light elements through much heavier elements and the capability of inspecting highly radioactive materials such as nuclear reactor fuel elements or control rods. For certain specialized applications and as a method to complement conventional radiography, neutron radiography has recently attracted the attention of industry and many governmental and university research laboratories as a nondestructive inspection technique with wide commercial and scientific application. The University of Texas neutron radiography facility installed in a vertical beam tube from the 250 kilowatt TRIGA reactor is described in this paper. Problems associated with the development of a neutron beam collimator, a radiation shield, and irradiation and photographic procedures are discussed. Radiographs using both neutrons and x-rays are compared to demonstrate various differences between the two methods. The use of neutron radiography for nondestructive inspection in both established and new areas of application is reviewed, and the feasibility of rapid nondestructive inspection of such items as radioactive materials, ammunition, electronic components, and biological systems is demonstrated. (auth)

**14223** UTILIZATION OF A LOW VOLTAGE ACCELERATOR FOR NEUTRON RADIOGRAPHY. Iddings, Frank A. (Louisiana State Univ., Baton Rouge); Bostrom, Norman A. pp 363-72 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

New low voltage accelerators having deuteron beam currents of over four milliamps provide usable neutron yields for use in neutron radiography. The neutron radiographs can be produced in exposures as short as one minute with efficient neutron converters and fast film. Metal foil converters give radiographs with exposures of 30 minutes or less. Neutron radiographs showing resolution obtainable with a simple set up and short exposures are presented. Data showing deuterium and tritium target lives to be long enough for use are presented. Results from a variety of conversion materials such as LiF/ZnS screen, Gd, and Ir are pictured. Also included are some preliminary data from work using an image intensifying system. Materials used as specimens for the neutron radiography include ammunition, electronic components, and several machined samples. (auth)

## Radioactive Material Handling

*Refer also to abstracts 13726, 14130, 14131, 16219, 16240, and 16316.*

**14224** (BNWL-1194) PRELIMINARY SAFETY ANALYSIS OF NEAR SURFACE STORAGE OF RADIOACTIVE WASTE AS SALT CAKES. Unruh, C. M. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 70p. Dep. CFSTI.

A detailed and critical examination of conceivable hazards of the In-Tank-Solidification (ITS) waste storage concept reveals no evidence to indicate that the concept is unsound. No natural hazards leading to the development of unsafe conditions were discovered. Anticipated uses of the nearby land will not jeopardize the multicentury isolation of the waste stored by the ITS concept. Radiological safety considerations indicate the ITS storage concept to be safe and to offer improved long-term waste storage compared to the present liquid storage methods. (auth)

**14225** (K-L-6249) FISSILE CLASS I SHIPMENT OF $UF_6$ "HEEL" CYLINDERS. Newlon, C. E.; Taylor, R. G. (Oak Ridge Gaseous Diffusion Plant, Tenn.). 19 Dec 1969. Contract W-7405-eng-26. 6p. Dep. CFSTI.

A nuclear safety analysis was made of in-service 5-, 8-, 12-, 30-, and 48-inch cylinders containing small quantities of $UF_6$ residual or heel that remain in the cylinders after normal usage. The evaluation indicated that neither protective packaging nor cylinder spacing is necessary for nuclear criticality safety, and such cylinders meet all safety standards of the U. S. Department of Transportation for Fissile Class I radioactive materials shipments. (J.C.W.)

**14226** (KFK-1065) TRAPPING OF FISSION PRODUCT IODINE WITH SILVER IMPREGNATED MOLECULAR SIEVES. Wilhelm, J. G. (Kernforschungszentrum, Karlsruhe (West Germany)). Oct 1969. 20p. (CONF-691104-4). Dep. CFSTI (U. S. Sales Only).

From International Congress on the Diffusion of Fission Products, Saclay, France.

The use of impregnated charcoal for the removal of fission product iodine is limited by relatively low desorption temperatures. In oxidizing gases, also ignition of the charcoal could occur. For trapping of fission product iodine in gases at high temperature and in the case of dangerous heat generation from fission product decay a nonflammable heat resistant adsorber material should be available for filtering devices. High removal efficiencies for methyl iodide and elementary iodine in air with relative humidities up to 100% were measured by filter beds made out of silver impregnated molecular sieve. Long time experiments were performed to test the removal efficiency of this material in dry air, steam-air mixtures, steam and helium; for air at temperatures up to 650°C. Experimental data are given for the $CH_3{}^{131}I$ removal efficiency of silver impregnated molecular sieve Linde 13 X as a function of the type, humidity and temperature of the sweep gas, the amount of silver used for impregnation, bed depth of the molecular sieve (and stay time, respectively), and the loading level of methyl iodide. The use of the molecular sieve in gaseous reactor coolants and for the cleanup of containment atmospheres is discussed. (auth)

**14227** (ORNL-NSIC-68) CASK DESIGNERS GUIDE: A GUIDE FOR THE DESIGN, FABRICATION, AND OPERATION OF SHIPPING CASKS FOR NUCLEAR APPLICATIONS. Shappert, L. B. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 237p. Dep. CFSTI.

The design of irradiated fuel shipping casks is governed by regulations that impose structural performance standards on the cask by a series of postulated accidents. This Guide provides cask design procedures and criteria, developed from extensive analysis and testing programs, that enable the designer to correlate the cask design with the performance of the cask as reliably as if the cask were subjected to a physical demonstration. The Guide covers design areas of cask structural integrity, heat transfer, criticality, shielding materials of construction, and fabrication techniques. This information is discussed within the framework of the AEC regulations, along with the rationale and the testing program that supported its development. It has been possible to provide design information in the important areas referred to in the current regulations. However, the regulations are constantly undergoing modification and often reinterpretation. Test programs and actual operating experience will continue to be useful in refining presently available data and modifying analyses discussed in this Guide. (auth)

**14228** (RFP-1411) ATMX-600 RAILCARS FOR RADIOACTIVE WASTE SHIPMENTS. Adcock, Frank E. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). 7 Jan 1970. Contract AT(29-1)-1106. 35p. Dep. CFSTI.

Shipping of fissile and large quantities of radioactive waste materials in ATMX-600 Series railcars is discussed. These massive (119,000 pounds light weight) double-walled steel cars, built and owned by the AEC, are ideal for shipping large volumes of waste materials to a burial site. Three roof sections of the car may be removed to expose the 9 × 9 × 50-foot cargo hold. The load limit is 101,000 pounds. Material may be packaged in either steel drums or plywood crates. Rapid loading and unloading is accomplished by pre-packaging the waste containers in USASI-ISO Standard 8 × 8 × 20-foot steel cargo containers. (auth)

**14229** (UCRL-71558) RENOVATING AND EQUIPPING THE LRL $\beta-\gamma$ HOT CELL FACILITY. Albrecht, E. D.; Johnson, J. M.; Stearns, E. H. (California Univ., Livermore. Lawrence Radiation Lab.). 3 Jul 1969. 20p. (CONF-691102-14). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

The High-Level $\beta-\gamma$ Hot Cell Facility at the Lawrence Radiation Laboratory, Livermore, California, has been completely renovated and equipped for post-irradiation examination of fuel and cladding test samples generated from Laboratory reactor programs. Internal renovation has included floor and ventilation modifications and installation of drop-in and waste removal chutes. Rolling roof doors have been installed over all cells. A master-slave manipulator repair room and warm machine shop with overhead manipulator storage have been added to the facility. The cells have been equipped with a variety of remotely operated equipment for capsule opening, specimen sectioning and chemical and metallographic analysis. (auth)

**14230** RADIATION PROTECTIVE ENCLOSURE HAVING A DOOR WHICH PIVOTS INTO THE ENCLOSURE. Schneeman, Justin G. U. S. Patent 3,488,495. 6 Jan 1970. Filed 20 Oct 1965.

A radiation protective enclosure is described which is constructed of a radiation absorbing material which generally surrounds a surface on which a specimen can be supported except for an opening in one portion thereof. A pivotal door also constructed of radiation absorbing material passes through the opening to close the same during the radiography process. The door mates with a depression in the support surface in the closed position to prevent the escape of radiation. The door shields the support surface from radiation from the source when the door is moved to the open position. (Offic. Gaz.)

**14231** UNDERGROUND STORAGE OF HARMFUL WASTES. Dolgikh, P. F.; Bakhurov, V. G. At. Energ. (USSR); 28: 70-1 (Jan 1970). (In Russian).

The underground storage of complex salt solutions, including radioactive wastes, in natural or explosion-produced caves in clay soils can be effective, especially with wastes treated and solidified with bentonite clay and lye. (R.V.J.)

**14232** DECONTAMINATION OF RADIOACTIVE WASTES FROM $^{55}$Fe PRODUCTION. Pavlov-Verevkin, B. S. At. Energ. (USSR); 28: 69-70(Jan 1970). (In Russian).

Deactivation of $^{55}$Fe with a half-life of 2.9 year which with K capture converts into the stable isotope $^{55}$Mn with irradiation energy of 5.9 keV was studied. Experiments on coagulation deactivation of $^{55}$Fe showed that the residual specific activity of solutions did not depend on the initial activity and ordinarily contained nearly $1 \times 10^{-9}$ Ci/l (which was approximately 30 fold lower than the permissible dose of $^{55}$Fe). It was shown that preliminary dilution of waste containing $^{55}$Fe was not necessary and good results were obtained by direct coagulation. The resulting specific activity of the material was below the PDC and the general amount of the radioisotope buried in a water basin was below the amount obtained with preliminary dilute material. (R.V.J.)

**14233** RESULTS OF A DEMONSTRATION AND OTHER STUDIES OF THE DISPOSAL OF HIGH-LEVEL SOLIDIFIED, RADIOACTIVE WASTES IN A SALT MINE. Bradshaw, R. L.; Empson, F. M.; McClain, W. C.; Houser, B. L. (Oak Ridge National Lab., Tenn.). Health Phys.; 18: 63-7(Jan 1970).

The radioactive phase of the demonstration disposal of high-level radioactive wastes in a salt mine was completed by the end of June 1967. The remainder of the mine experiments were terminated, and The Carey Salt Company's Lyons, Kansas, mine was placed on a standby basis, beginning February 1968. During the 19-month operation of the radioactive demonstration, the average dose to the salt over the length of the radioactive container holes was about $8 \times 10^8$ rads, and the peak dose was about $10^9$ rads. A study of the economics of disposal-in-salt was completed. The calculated cost per kilowatt-hour of electricity generated ranged from about $20 \times 10^{-3}$ to $2 \times 10^{-3}$ mill for wastes aged 1 yr and 30 yr, respectively. To summarize, it may be said that most of the major technical problems regarding disposal in salt have been resolved. The feasibility and safety of handling highly radioactive materials in an underground environment have been demonstrated. The stability of the salt under the effects of heat and radiation was shown, as well as the capability of solving minor structural problems by standard mining techniques. The data obtained on the creep and plastic flow characteristics of the salt should make it possible to arrive at a suitable mine design for a disposal facility. A study of the economics of disposal in salt mines indicates that this method will be compatible with competitive nuclear power. All of these items combined leads one to the conclusion that burial in salt mines is one of the better, if not the best, methods for the ultimate disposal of high-level solidified wastes. (auth)

**14234** CRITICALITY: A REVIEW OF BASIC CONCEPTS AND THEIR APPLICATIONS. PART II. Chalmers, J. H.; O'Sullivan, R. A.; Rushton, K. C.; Walker, G. (United Kingdom Atomic Energy Authority, Risley, Eng.). J. Brit. Nucl. Energy Soc.; 9: 55-6(Jan 1970).

Consideration is given to ways in which the criteria associated with operational nuclear safety evaluation may be applied to typical fuel handling processes and to the transport of fissile material. Storage of fuel elements, dissolution of spent fuel, and a typical evaporation cycle are discussed. Particular attention is paid to accidental damage during transport and problems of the individual package. (UK)

**14235** SAFEGUARD AND CONTROL TECHNIQUES FOR NUCLEAR MATERIALS. Miranda, Ugo. Euro-Spectra; 8: 112-18(Dec 1969).

The Euratom safeguards and controls system is designed to discourage, on the territory of the Community, the misappropriation of fissile materials for purposes other than those for which they were originally intended, but is nonetheless not a policing system. (auth)

**14236** STATUS OF INVESTIGATIONS OF SALT FORMATIONS FOR DISPOSAL OF HIGHLY RADIOACTIVE POWER-REACTOR WASTES. McClain, W. C.; Bradshaw, R. L. Nucl. Safety; 11: 130-41(Mar-Apr 1970).

A committee of the National Academy of Sciences first suggested the use of salt formations for the disposal of radioactive wastes in 1955, and feasibility studies began at Oak Ridge National Laboratory and elsewhere as early at 1957. By the early 1960's, emphasis had shifted from direct disposal of liquid wastes to solidification and disposal of the resulting solids. A concept for disposal of such solids in a salt mine was developed, and preparations for a demonstration experiment began in 1963. The radioactive phase of this demonstration began in November 1965 and successfully demonstrated the feasibility and safety of handling highly radioactive materials in an underground environment. This experiment also demonstrated the stability of salt under the effects of heat and radiation. Data obtained on the creep and plastic flow characteristics of salt have made it possible to arrive at a suitable mine design for a disposal facility. A study of the economics of disposal in salt mines indicates that this method will be compatible with competitive nuclear power. An analysis of the projected power-reactor wastes and the safety considerations involved points to the need for a government-owned waste repository to be in operation before 1980. 36 references. (auth)

## Vacuum Engineering

*Refer also to abstract 14183.*

**14237** SOME PROBLEMS ASSOCIATED WITH THE ATTAINMENT OF ULTRAHIGH VACUUM. Fulker, M. J.; Baker, M. A.; Laurenson, L. (Edwards High Vacuum International Ltd., Crawley, Eng.). Vacuum; 19: 555-60(Dec 1969).

The behavior of pumps used in the attainment of ultrahigh vacuum has been studied. Sorption pumps remove gas selectively and as a result leave high partial pressures of neon and helium which are likewise poorly adsorbed by getter-ion pumps. Oil filled rotary pumps overcome this problem but are a source of organic contamination unless carefully trapped. Recent improvements in Penning pump design in which the phenomena of argon instability can now be overcome are discussed. A mass spectrum is shown for a system exhausted by a combination of Penning and sublimation pumps, exhausted by an alumina trapped rotary pump during the prebaking period. (auth) (UK)

**14238** 70,000 l/s CONTINUOUS HYDROGEN PUMPING BETWEEN $10^{-6}$ AND $10^{-8}$ TORR., IN A 3m$^3$ LIGHT ALLOY VESSEL WITHOUT THERMAL OUTGASSING. Geller, R. (CEN, Saclay, France). Bull. Inform. Sci. Tech. (Paris); No. 142, 39-49(Nov 1969). (In French).

An industrial prototype titanium evaporation pump is described which is distinguished by its stable pumping rate during several hours of continuous operation at pressures lower than $5.10^{-6}$ torr. Measurements are given of the pumping rate, the sticking coefficient, and the accommodation coefficient of this pump when it is placed in a large vessel where problems of conductance are no longer involved. It is shown that by coupling this type of pump with a turbomolecular pump it is possible to obtain an ultrahigh vacuum in vessels of several cubic meters capacity without using ultrahigh vacuum technology. (auth)

**14239** THE VACUUM SYSTEM OF SOLIS (SOREQ ON-LINE ISOTOPE SEPARATOR). Oron, M. (Soreq Nuclear Research Centre, Yavne, Israel). Vacuum; 19: 567-70(Dec 1969).

The vacuum system associated with the Soreq On-Line Separator (SOLIS) is described. The separator is designed to separate short-lived fission products produced by an external neutron beam at the IRR-1 Reactor at Soreq. Various parts of the system are described, with special emphasis on the radiation and radioactive contamination problems in the design. Some data showing the influence of the vacuum in the system on the performance and on beam transmission and cross-contamination of the separated masses are presented. (auth) (UK)

**14240** AN ULTRAHIGH-VACUUM ENCLOSURE. (to Commissariat a l'Energie Atomique). British Patent 1,181,750. 18 Feb 1970. Priority date 5 Jan 1968, France.

A design of an ultrahigh vacuum vessel for housing equipment for the deposition of metallic films on a substrate by vacuum evaporation is described. The design of the vessel allows the cryogenic pump or cold trap to be isolated when the vessel is opened. (J.C.W.)

# INSTRUMENTATION

## Radiation Detection Instruments

*Refer also to abstract 16325.*

### General Detectors and Monitors

*Refer also to abstracts 14314, 14323, 14324, 14329, 14367, 14534, and 16312.*

**14241** (AD-695421) SUGGESTED DEVICE FOR PRECISE MEASUREMENT OF PARTICLE TRAJECTORIES. Hofstadter, Robert (Stanford Univ., Calif. High-Energy Physics Lab.). Jul 1969. Contract Nonr-225(67). 16p. (HEPL-607). CFSTI.

A suggested device for particle detection and measurement is described in which the intersection of a high energy particle's trajectory with a detecting plane may be measured with a potential precision of 0.01 mm or better. (auth) (USGRDR)

**14242** (AEC-tr-7140) RADIATION MONITORING SYSTEM IN SASEBO HARBOR. Akabane, Nobuhisa. Translated from Genshiryoku Kogyo; 15: No. 3, 47-50(1969). 9p. Dep. CFSTI.

Unlike the case of ordinary atomic installations where the radiation control is carried out on their own responsibility, the radiation control in harbors subjected to the port-call of atomic warships must be performed by the Government. In the Sasebo harbor, from 1964 to April 1968, there were a total of 13 portcalls by U. S. atomic warships. When the atomic submarine Swordfish was in the harbor, the monitoring posts recorded radioactivities 10 to 20 times higher than normal. In this connection and for other reasons, the radiation monitoring system in the Sasebo harbor was strengthened. The radiation monitoring system in the Sasebo harbor is described in the following: fundamentals behind carrying out radiation monitoring in the harbor; occurrence of a problem at the port-call of the Swordfish; the exchange of the U. S.–Japan memorandum; expansion of the system of monitoring facilities including monitoring posts, measuring instruments for monitoring boats, nuclide analyzers, etc.; strengthening of the monitoring set-up for personnel, the monitoring activities, and reporting and announcing the results of monitoring the first portcall of a U. S. atomic submarine after the Swordfish problem. (NSA of Japan)

**14243** (ANL-7616) THE COMPLETE ($\alpha$, $\beta$, $\gamma$) PERSONNEL MONITOR. Fergus, Richard W. (Argonne National Lab., Ill.). Oct 1969. Contract W-31-109-eng-38. 18p. Dep. CFSTI.

A personnel hand and shoe monitor, PERCI (PERsonnel Contamination Instrumentation), has been developed to provide simultaneous detection of alpha, beta, and/or gamma contamination. Automatic operation provides uniform survey sensitivity that is independent of the user. Logic circuitry prevents incomplete surveys and causes "go" or "no-go" instructions to be flashed on an illuminated display panel. Alpha, beta, and/or gamma events for each channel are detected with a large-area, gas-flow detector and pulse-separation circuitry. A unique background compensation feature implements statistical computation for each survey by comparing the actual number of events during the survey cycle with a number predicted from the background events preceding the cycle. Reliable operation with stable calibration is assured with solid-state circuitry and appropriate feedback. Consistent performance with infrequent false alarms characterizes the operation of this monitor. Sensitivity has been demonstrated on many occasions when the monitor has detected contamination on the user that could not be located with conventional survey instruments. (auth)

**14244** (CEA-CONF-1432) EFFICIENCY AND TIME RESOLUTION FOR LARGE Ge(Li) GAMMA DETECTORS USED IN FAST NEUTRON EXPERIMENTS. Sonrel, C.; Perrin, P.; Maurel, M.; Mougin, A. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). [1969]. 21p. Dep. CFSTI (U. S. Sales Only).

The intrinsic efficiency, energy and time resolution for the range of 5 to 17 MeV have been measured for some large (20 to 120 $cm^3$) Ge(Li) coaxial detectors. The possibility of (n,$\gamma$) and (n,n'$\gamma$) experiments has been checked using a multiparametric data system. (auth)

**14245** (CEA-N-1264) SECONDARY EMISSION DETECTOR FOR THERMAL NEUTRONS. Verdant, Robert (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Jan 1970. 45p. (In French). Dep. CFSTI (U. S. Sales Only).

In this thermal neutron detector, the heavy particles coming from a (n,$\alpha$) or (n,f) reaction in a given material (B or U), induce a secondary emission when crossing a target (Al) directly deposited on this material. The secondary electrons are detected through a classical electron multiplier. The influence of gamma radiation on the detector was tested; the highest permitted gamma radiation appears to be $10^3$ $R.h^{-1}$. It was attempted to determine the suitable thicknesses of both the target and the converter for a given neutron flux. Such a detector could be placed, for instance, in the biological protection part of a reactor, where the temperature is lower than 100°C and the gamma radiation does not exceed a few hundreds of $R.h^{-1}$. The influence of the emission of fission fragments on the residual pressure of the detector was studied. (France)

**14246** (CONF-681210(Vol.2)) PROCEEDINGS OF THE NUCLEAR PHYSICS AND SOLID STATE PHYSICS SYMPOSIUM, BOMBAY, DECEMBER 28–31, 1968. VOLUME II. NUCLEAR PHYSICS (CONTRIBUTED PAPERS). (Department of Atomic Energy, Bombay (India). Physics Committee). 1968. 422p.

Separate entries are included for 82 of the 94 papers presented. (D.C.C.)

*For abstracts of individual papers see: 14253–14257, 14315, 14356, 15129, 15283, 15284, 15302, 15353, 15727, 15767–15769, 15798, 15825–15838, 15884–15904, 15990–16002, 16095–16097, 16165–16167, 16244–16247, 16289–16291, 16311–16313, and 16325.*

**14247** (LA-4263) PHOTOTUBE GAIN STABILIZATION USING GALLIUM PHOSPHIDE LIGHT EMITTING DIODES. Leydig, Robert; Perkins, Roger B. (Los Alamos Scientific Lab., N. Mex.). 16 Sep 1969. Contract W-7405-eng-36. 5p. Dep. CFSTI.

Certain characteristics of three commercially available gallium phosphide light-emitting diodes have been measured. Preliminary tests of their effectiveness in photomultiplier gain stabilization systems have been made. It is concluded that the use of such diodes is highly effective for gain stabilization, providing that the environment is temperature stabilized. (auth)

**14248** (LIB/Trans-241) EFFICIENCY AND TIME RESOLUTION OF A 120 $cm^3$ Ge(Li) DETECTOR. Henck, R.; Siffert, P.; Miehe, J.; Coche, A. Translated by W. J. Buykx (AAEC, Research Establishment, Lucas Heights), from Nucl. Instrum. Methods; 74: 169-70(1969). 4p. Dep. CFSTI (U. S. Sales Only).

An abstract of this paper, prepared from the original language, appeared as NSA 23: 50158 (1969). (Australia)

**14249** (UCRL-19413) EFFECTS AND CONTROL OF SURFACE STATES DURING LITHIUM ION DRIFT IN SILICON. Lothrop, Robert P. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 43p. Dep. CFSTI.

Parameters for fabrication of lithium-drifted silicon semiconductor detectors with good voltage and current characteristics are discussed. The nature of the intrinsic surface, evaluation of surface state effects, pre-drift surface treatment, and surface state control during drift by gas mixtures and by liquids are considered. (W.H.K.)

**14250** AMPLIFICATION OF CHARGED PARTICLE TRACKS IN VERY FINE-GRAIN NUCLEAR EMULSIONS. Perfilov, N. A.; Novikova, N. R.; Zakhanov, V. I. (Khlopin Radium Inst., USSR). Zh. Nauch. Prikl. Fotogr. Kinematogr.; 14: No. 3, 207-8(May-Jun 1969). (In Russian).

Photographic amplification of charged particle tracks in fine-grain nuclear emulsion was achieved by using physical developer with p-oxyphenylglycine. Microphotographs of particles tracks before and after amplification are given for the products of $^6Li(^4He + {}^3He)$ spallation, proton recoil tracks from a Po–Be source, and $\alpha$ particles from $^{210}Po$. (R.V.J.)

**14251** USE OF IONIZATION CHAMBERS FOR THE ABSORBED DOSE CALIBRATION OF HIGH ENERGY ELECTRON BEAM THERAPY UNITS. Almond, P. R. (Univ. of Texas, Houston). Int. J. Appl. Radiat. Isotop.; 21: 1-3(Jan 1970).

A system is proposed for high-energy electron-beam calibration using small calibrated thimble ionization chambers. It is suggested that $D = R \cdot N \cdot C_F$ when D is the dose in rad, R the chamber reading, N the exposure factor for $^{60}Co$ and $C_F$ is the overall conversion factor dependent upon the mean energy of the primary electrons at the point of measurements. Two sets of experimental data involving several different makes of chambers are compared with theoretical calculations and excellent agreement is found within experimental limits. A set of $C_F$ factors is proposed for different initial-energy electrons when a standard calibration phantom is used. (auth)

**14252** METHOD FOR CONTINUOUS DETERMINATION OF THE ZERO LEVEL OF A NEUTRON MONITOR. Blokh, Ya. L. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.); 9: 473-4(1969).

Translated from Geomagn. Aeron.; 9: 579-80(1969).

A method is proposed for automatically recording the zero level for each section of the neutron monitor with an accuracy of ~0.01% or higher. The idea of the method is based on the fact that the discrimination characteristic has two characteristic segments: a descending segment and a plateau. (W.D.M.)

**14253** A METHOD OF PHOTOPEAK SHARPENING IN SCINTILLATION SPECTROMETERS. Roy, S. C.; Chatterjee, Arun; Ghose, A. M. (Bose Inst., Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 193-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

A scintillation detector arrangement is described for improving the effective resolution by reducing the statistical fluctuations in the photomultiplier. A perforated aluminum reflector is mounted in the light guide to divide the light output from the scintillation detector between two photomultipliers. (W.H.K.)

**14254** AN INTERNAL COUNTER CONTROLLED LOW PRESSURE CLOUD CHAMBER FOR THE STUDY OF NUCLEAR FISSION PHENOMENA. Rama Rao, M. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 216-18(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

A low-pressure cloud chamber is described with a double ionization detector trigger system. The ionization detector and the cloud chamber are integrated with a common gas vapor filling. The detector system is used for photographing both binary and ternary fission events. (W.H.K.)

**14255** CONSTRUCTION AND OPERATION OF A LOW LEVEL, WINDOWLESS 4π COUNTER FOR ROUTINE USE IN TRACER STUDIES. Udupa, K. B.; Nag, B. D. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 219-22(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The construction and operation of a compact windowless 4π Geiger–Mueller counter with low background for radioactive tracer studies are briefly described. The two anodes are operated in anticoincidence for background reduction, and the counter has a circular sample changer with a pre-flush position for ease of operation. (W.H.K.)

**14256** SEMICONDUCTOR X-RAY SPECTROMETER. Kataria, S. K.; Kapoor, S. S.; Rama Rao, P. N.; Ballal, B. R.; Murthy, S. R. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 223-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

A lithium-drifted silicon x-ray spectrometer is described, and some applications are discussed. The energy resolution of the spectrometer is about 800 eV. (W.H.K.)

**14257** MONTE CARLO CALCULATION OF GAMMA-RAY RESPONSE CHARACTERISTICS OF CYLINDRICAL Ge(Li) DETECTORS. Lal, B.; Iyengar, K. V. K. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 228-33(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Calculated response function characteristics including full energy peak efficiency and double escape peak efficiency are given for various-sized cylindrical lithium-drifted germanium detectors. The Monte Carlo calculational method is discussed. (W.H.K.)

**14258** VARIABLE TIME-LAPSE VIDEOSCINTISCOPE: A MODIFICATION OF THE SCINTILLATION CAMERA DESIGNED FOR RAPID FLOW STUDIES. Kriss, Joseph P.; Bonner, William A.; Levinthal, Elliott C. (Stanford Univ. School of Medicine, Calif.). J. Nucl. Med.; 10: 249-51(May 1969).

The variable time-lapse videoscintiscope which automatically records scintillation camera images over selected time intervals is described. (W.H.K.)

**14259** MEASUREMENT OF 14 MeV NEUTRON FLUX DENSITY BY FISSION TRACK METHOD. Nakanishi, T.; Sakanoue, M. (Kanazawa Univ., Japan). Radiochem. Radioanal. Lett.; 2: 313-19(27 Dec 1969).

The fission track method for measuring neutron fluence was applied to a measurement of the neutron flux distribution in the neighborhood of a disk-shaped tritium target of a commercial 14 MeV neutron generator. By combining a uniform fission source of vacuum-evaporated natural uranium with muscovite track detector, the minute variation of neutron flux density over the area of the cooling cap was measured easily, and the decrease of flux density with distance from the cooling cap was also estimated. (auth)

**14260** LIQUID SCINTILLATION COUNTING APPARATUS. Utting, George R. (to Picker Corp.). U. S. Patent 3,488,497. 6 Jan 1970. Filed 22 Oct 1965.

The method and apparatus for testing a plurality of liquid radioactive samples contained in uniform sample vials are described. The samples are advanced seriatim by a conveyor to a location where they are temporarily diverted, tested for at least two different types of radioactivity, one of which is by liquid scintillation techniques, and returned to their respective seriatim positions on the conveyor. (Offic. Gaz.)

**14261** ESTIMATE OF DETECTION LEVELS AND ACCURACY OF RADIOMETRY OF LOW-LEVEL ACTIVITIES. Malykhin, V. M.; Golubev, B. A. (Inst. of Biophysics, Moscow). Prib. Tekh. Eksp., No. 3, 87-8(May-June 1969). (In Russian).

A nomogram describing the relations between the activity of the sample and the duration and accuracy of the measurement efficiency and the background permitting a wide range of measuring variables and graphical estimation of any of them is given. An example of detection activity of 1 nCi in a device with an efficiency of 5% and 500 pulses/min background was measured with 5% accuracy per 80 min. (R.V.J.)

**14262** HELIUM MULTIWIRE DETECTOR FOR THERMAL NEUTRONS. Karimov, I. A.; Shitikov, Yu. L.; Zemlyanov, M. G.; Mironov, S. P. Prib. Tekh. Eksp.; No. 5, 55-7(Sep-Oct 1969). (In Russian).

The construction and operation of a tube-type helium multiwire proportional detector for thermal neutrons are described. The efficiency of the detector for thermal neutrons is ~90%. The tubular construction of the detector reduces the shielding of the counting volume by construction materials. (tr-auth)

**14263** OPERATION ANOMALIES OF PROPORTIONAL COUNTERS IN THE REGION OF ULTRASOFT X RAYS. Smirnov, V. N. (Central Scientific-Research Inst. of Ferrous Metallurgy, Moscow). Prib. Tekh. Eksp.; No. 5, 57-9(Sep-Oct 1969). (In Russian).

The relation of the pulse amplitudes of the proportional counter to the intensity of ultrasoft x rays was examined. For the K lines of B, C, and F, it was shown that the shift of the peak of the amplitude distribution for the counter with an anode fiber of 0.05 mm diameter reaches 25% and more, relative to the recorded intensity. Increasing the anode fiber to 0.13 mm decreases this shift for F to 3% and the shift for B and C is practically negligible. (tr-auth)

**14264** TESTS OF SURFACE-BARRIER SEMICONDUCTOR DETECTORS AT LIQUID HELIUM TEMPERATURES. Tambovtsev, D. I.; Kozlovskii, L. K. (Physico-Energetics Inst., Obninsk, USSR). Prib. Tekh. Eksp.; No. 5, 59-61(Sep-Oct 1969). (In Russian).

It was shown that surface-barrier Si and Ge detectors of standard fabrication were completely reliable down to T = 4.2°K. Only thermostable contacts were necessary. Several construction modifications were proposed for the detectors. (tr-auth)

**14265** EFFECT OF THE METHOD OF ETCHING ON THE STATE OF THE SURFACE AND THE ENERGY RESOLUTION OF SILICON SURFACE-BARRIER DETECTORS. Protsenko, A. V.; Korol, Z. I.; Korol, V. M. (Rostov State Univ., USSR). Prib. Tekh. Eksp.; No. 5, 61-3(Sep-Oct 1969). (In Russian).

The results of investigating the state of the surface and the energy resolution of three Si surface-barrier detectors are given. It was established that the etching solution and etching time have an effect on the purity of the surface, whereas the energy resolution for a 5.80-MeV alpha particle does not depend on these factors. (tr-auth)

**14266** ALL-METAL WINDOWLESS VESSEL FOR LIQUID SCINTILLATORS. Shutko, A. N. (Central-Scientific Research X-Radiology Inst., Leningrad). Prib. Tekh. Eksp.; No. 5, 64-5 (Sep-Oct 1969). (In Russian).

The construction of simple all-metal vessels providing optical contact of the liquid scintillator directly to the photomultiplier window that permits a 20% increase in the efficiency for tritium determination in comparison to the generally accepted system of silicone vessel contacts with a glass window is described. (tr-auth)

**14267** DEVICES FOR MONITORING THE GAMMA RADIATION FROM A RADIATION SOURCE. (to Sulzer Brothers Ltd.). British Patent 1,175,932. 1 Jan 1970. Priority date 19 Apr 1967, Switzerland.

A device for monitoring the gamma radiation from a radiation source situated behind a radiation shielding wall is described. The device comprises a screen which is situated in or on the shielding wall and which emits visible light under the influence of gamma radiation and, also, a light guide extending from the screen through the shielding wall away from the source. Zinc sulfide is used as the detector. (W.H.K.)

**14268** LOCKABLE UNIT WITH VIOLATION INDICATOR. Avice, Pierre; Bressy, Roger; Fitoussi, Lucien; Girouy, Andre (to Commissariat a l'Energie Atomique). British Patent 1,175,125. 23 Dec 1969. Priority date 14 Dec 1966, France.

A lockable unit for portable individual radioactivity alarm detectors is described which reveals any violation or tampering with the unit. (W.H.K.)

**14269** FLOW COUNTER FOR MEASUREMENT OF RADIOACTIVE MATERIALS. Wegner, Lutz-Axel British Patent 1,174,266. 17 Dec 1969. Priority date 10 Dec 1965, Germany.

The design and operation of a flow counter for measuring radioactive samples are described. To stabilize and control the counting rate, the potential difference between the sample surface and the metal plate at the chamber entrance is controlled. (W.H.K.)

**14270** A DETECTOR FOR DETERMINING THE DISTRIBUTION OF RADIOACTIVE MATERIALS. (to Siemens Aktiengesellschaft). British Patent 1,174,558. 17 Dec 1969. Priority date 3 Mar 1967, Germany.

A scintillation camera is described which employs an image intensifier with a plurality of electron multipliers in conjunction with a large scintillation crystal plate. (W.H.K.)

**14271** IMPROVEMENTS IN SEMICONDUCTOR DEVICES. (to Philips Electronic and Associated Industries Ltd.). British Patent 1,171,395. 19 Nov 1969. Priority date 1 Mar 1966, Netherlands.

A semiconductor device for detecting and measuring radiation is described. It comprises a single crystal disc of a semiconductor material of diamond crystal structure with an electrode on each of the two opposite major surfaces of the disc, the normal to the disc being oriented towards an irrational direction at an angle of 1° from a ⟨432⟩-direction of the single crystal, towards the [111]-direction. The maximum deviation in any direction of the normal from the said irrational direction is 5°. (W.H.K.)

**14272** THE EFFICIENCY OF RADIATION DETECTION BY PHOTOGRAPHIC FILMS: STATE-OF-THE-ART AND METHODS OF IMPROVEMENT. Bird, George R.; Jones, R. Clark; Ames, Allan E. (Polaroid Corp., Cambridge, Mass.). Appl. Opt.; 8: 2389-2405(Dec 1969).

The performance of photographic films as radiation detectors has rested at a state-of-the-art plateau for some time. In terms of detective quantum efficiency (abbreviated DQE) this plateau is at about 1% for the best films, which 1% should be compared with 100% for an ideal photon counter. The physical causes for the 100-fold discrepancy between reality and ideal performance are examined in detail: incomplete light absorption; a small inefficiency in converting photons into photoelectrons; a large loss due to recombination of electrons with holes; a small loss dictated by a four-atom threshold; a small loss dictated by random position; a large loss from the use of a wide dispersion of grain sizes. These factors account quantitatively for substantially all of the discrepancy between reality and ideal performance. We show that the recombination loss is a necessity that must ordinarily be tolerated in order to secure a good shelf life for films. Part of the loss may be recouped by the well-known method of latensification. Films with a wide dispersion of grain sizes will have a higher DQE if the grains operate at a threshold of two processed photons instead of four. Latensification permits one to approach the two-atom threshold condition. (auth)

**14273** PHOTOGRAPHIC EMULSION LAYER AS A THREE-DIMENSIONAL RECORDING MEDIUM. Berg, W. F. (Eidgenoessische Technische Hochschule, Zurich). Appl. Opt.; 8: 2407-16(Dec 1969).

In order to understand how a photographic material responds to radiation, its depth must be taken into account. For analysis, the material is imagined to be built up of "elementary layers." The three characteristics: modulation transfer, density, and granularity, completely characterize the material and the resulting image. For parallel light both in exposure and density readout these characteristics are additive from those of the elementary layers. Methods for realizing and measuring the properties of elementary layers in any given material are described. The modulation transfer function is found to be considerably degraded for the lower elementary layers, which also make a relatively large contribution to the lower spatial frequencies of the noise power spectrum. (auth)

**14274** METHOD AND APPARATUS FOR RADIOACTIVITY ANALYSIS. Morgan, Ira L.; Hall, James D. (to Texas Nuclear Corp.). U. S. Patent 3,493,750. 3 Feb 1970. Filed 10 Apr 1967.

Individual energy-peaks of a scintillation-counter pulse-height spectrum are discriminated in appropriate channels corresponding to all peaks above the lowest to be measured. The pulses in each channel above the lowest are fed to all lower channels through time-division gates, and the fraction so derived is continually subtracted from the pulse count in the respective lower channels. Output counting-rate in each channel varies only with variation of the radiation of the energy to which it corresponds. (Offic. Gaz.)

**14275** VACUUM FISSION CHAMBER POSSESSING DIRECTIONAL SENSITIVITY FOR RECORDING OF NEUTRONS. Malyshev, E. K.; Dmitriev, A. B.; Belozerov, V. G. At. Energ. (USSR); 27: 347-8(Oct 1969). (In Russian).

In ordinary ionization chambers, the linear range of measured currents does not extend beyond an electrode current density of 10 $\mu A/cm^2$ at 50 V. Use of a vacuum chamber allows to broaden the thermal flux measurement range. The fissile mixture was deposited electrolytically on the internal electrode fastened on beryllium oxide insulators. The 10-mm diameter chamber was evacuated to a pressure of $10^{-3}$ torr. By determining the neutron flux and the amount of fissioning material, it is possible to calculate the number of electrons emitted by the electrodes: about 2000 secondary electrons correspond to one fission fragment. The chamber was used in a heavy-water and the SM-2 reactor. (TTT)

**14276** COUNTING STATISTICS IN RADIOACTIVE SAMPLING APPARATUS BY SAMPLE ROTATION. Olson, Robert E. (to Packard Instrument Co., Inc.). U. S. Patent 3,493,749. 3 Feb 1970. Filed 20 May 1966.

In an apparatus for detecting and measuring radioactivity emanating from a sample, the statistical counting accuracy is improved by rotating the sample during a predetermined counting or measuring period. Particularly in conjunction with liquid scintillation counting, the sample is preferably rotated either an integral number of revolutions, or a large number of revolutions, during the counting and measuring period. (Offic. Gaz.)

**14277** BASIC FUNCTION UNITS AND SUB-ASSEMBLIES FOR HEALTH PHYSICS NEAR NUCLEAR CENTERS. Lejaille, J.; Kraemer, R. Atompraxis; 15: 421-2; 425(Nov-Dec 1969). (In German).

Alcatel, Thomson-CSF and Merlin-Gerin have industrialized the radiation-measuring equipment units studies by the CEA (French Atomic Energy Commission), constituting the new generation of Health Physics equipment near nuclear centers. The control technique of radiation level on sites and in premises housing a reactor, or an accelerator or again, in a radiochemistry plant, meet the requirements of measuring points dispersion and of data centralization, thus allowing concurrently to optimize the operation time of the installations and to increase workers safety. Thanks to their modular design, the new nuclear electronics basic function units constitute the starting point from which the user can wholly form his own installation with a minimum of equipment. The cost-price of such an installation is therefore cheaper than that of a standard installation when the number of channels is greater than eight. In fact, the specialization of circuits into standard basic function units permits great flexibility both for design of the assembly and when an extension or a modification is needed. Each basic function unit ensures one elementary electronic function and is provided in plug-in unit form. The drawers are designed to contain the basic function units associated with the detectors and preamplifiers, they form self-contained channels. Associated in boards, they constitute sub-units for a more complex installation, in multiples of 6, 18, 30 or 60 channels. (auth)

**14278** NUCLEAR ELECTRONICS: NUMERICAL CALCULATION OF FAST ELECTRONIC CIRCUITS. Stanek, F. W. (Oskar-von-Miller Polytechnikum, Munich). Kerntechnik; 11: 653-61(Nov 1969). (In German and English).

The numerical computation of the transmission behavior of linear and nonlinear pulse circuits by means of an automatic procedure which can be used to solve systems of linear as well as of nonlinear differential equations is described. The DIFFSYS routine used with this procedure requires programming in ALGOL.

The transient responses of a charge-sensitive amplifier, of a trigger threshold and of a univibrator are discussed and computed as examples. (auth)

**14279** DEPENDENCE BETWEEN EXTRAPOLATED INTENSITY OF IONIZATION CURRENT AND INITIAL RESISTANCE FOR THE LIQUID FILLED IONIZATION CHAMBERS. Terlecki, J.; Ostrowska, T.; Zurawska, E. (School of Education, Danzig). Zesz. Nauk. Mat., Fiz., Chem., Wyzsza Szkola Pedagog. Gdansku; 9: 33-42(1969). (In Polish).

It has been proved experimentally and substantiated theoretically that the ratio of ionization current's density and the initial electrical conductivity of the liquid-filled chambers is constant. It does not show any dependence on the dose rate of absorbed photon radiation (X). The values of these constants have been determined for plane-parallel chambers filled with: n-hexane, n-octane, n-decane, and carbon tetrachloride and it has been shown on what physical characteristics and radiation properties of the liquid they depend. (auth)

**14280** STUDY OF THE CHARACTERISTICS OF RADIATION DETECTORS WITH SEMICONDUCTOR DEVICES. Poenaru, Dorin N. (Inst. of Atomic Physics, Bucharest). Stud. Cercet. Fiz.; 21: 873-916(1969). (In Rumanian).

Topics include penetration of the nuclear radiation into the substance; gathering of an electron-hole pair in semiconductor detectors; the form of electrical impulse given by detectors with semiconductors; current impulses from detectors with semiconductors; special circuits of amplification used in apparatus associated to semiconductor detectors; and spectrometer for heavy charged particles. (auth)

**14281** IMPROVEMENTS IN OR RELATING TO LIQUID SCINTILLATION SPECTRAL ANALYSIS. (to Packard Instrument Co., Inc.). British Patent 1,175,626. 23 Dec 1969. Priority date 14 Apr 1967, United States.

An apparatus is described for simulating quenching in test samples containing one or more radioactive isotopes disposed in a liquid scintillator. This apparatus comprises a light transducer, means for positioning a sample adjacent to and in a light transmission relationship with the transducer so as to establish a sample-transducer combination, which permits counting of light scintillations occurring in the sample. By means of various devices, including means for reducing the light input to the transducer and means for moving the transducer away from the sample in controlled increments, the counting statistics of the sample-transducer combination are altered so as to simulate quenching in the sample. (B.L.M.)

**14282** CHERENKOV COUNTING OF RADIONUCLIDES. Parker, R. P. (Inst. of Cancer Research, Sutton, Eng.). Health Phys.; 18: 175-6(Feb 1970).

Following the publication of a note (Johnson, J. E.; Hartsuck, J. M.; Health Phys., 16: 755(1969)) on the subject of counting $^{42}K$ by the emitted Cherenkov radiation, it is stated that this technique has been in use for some years. Efficiencies ranging from 5% for $^{36}Cl$ to 76% for $^{42}K$ are quoted and it is stated that since the advent of automatic liquid counting, the system is used routinely. The advantages are: ease of source preparation, lack of chemical quenching, and the samples are recoverable. The main disadvantage is color quenching but correction can be made for this. (UK)

**14283** INSTRUMENTATION FOR SOUNDING GAMMA AND BETA RADIATION AND RESULTS OF CYCLIC EXPERIMENTS TO DIFFERENTIATE THE POLLUTION TO ROME FROM THE SECOND AND THIRD CHINESE NUCLEAR TESTS. Pavesi, Benvenuto. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 493-515 (Jun 1966). (In Italian).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

An instrument is described for evaluating radioactive pollution by the measurement of $\gamma$ and $\beta$ activities at different heights by means of a radiosonde. A report is given of the results of two series of soundings made over Rome at the time of the second and third Chinese nuclear tests. A first analysis of these results is discussed. (auth)

**14284** MINIATURE PULSED LIGHT SOURCE AND APPLICATIONS TO PARTICLE DETECTOR DESIGN. Ely, J. T. A.; Ringle, J. C. (Univ. of Washington, Seattle). Rev. Sci. Instrum.; 41: 207-11(Feb 1970).

An alpha emitter ($^{241}Am$) deposited externally as a thin source on a small NaI(Tl) crystal has been employed as a miniature light pulser. Applications include photomultiplier tube calibration and stabilization, and high precision light collection efficiency mappings for design optimization of scintillation and Cherenkov detectors. Improved resolution has been reported by Menefee and Cho [IEEE Trans. Nucl. Sci. NS-13, No. 3, 159(1966)] for NaI(Tl) crystals doped internally with $^{241}Am$. (auth)

## *Nuclear Spectroscopic Instrumentation*

*Refer also to abstracts 14373 and 15822.*

**14285** (CEA-N-1238) ANALYSIS OF PULSE SPECTRA: THE CORAUT PROGRAM. Manent, Georges (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Jan 1970. 55p. (In French). Dep. CFSTI (U. S. Sales Only).

With this program, it is possible to analyze a pulse spectrum produced by a spectrometer under the following conditions: In a composite spectrum, the total absorption peak characteristic of the isotope is isolated and compared to that of a standard source. It is assumed that in the composite spectrum the peak is accompanied by a linear background noise. The linear noise is then defined around this peak. The program can compare the measured spectrum to the reference spectrum using a least squares method. It makes an automatic correction for the drift by resetting the reference with respect to the measurement using elementary operations equivalent to changes in the discrimination threshold (zero channel threshold) or to the spectrometer gain. (auth) (France)

**14286** (CEA-R-3822) GAMMA SPECTRUM MEASUREMENT IN A SWIMMING-POOL-TYPE REACTOR. Pla, Enrique (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Nov 1969. 70p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Univ. of Grenoble, Faculte des Sciences, France.

The design of a spectrometer for gamma energies of between 0.3 and 10 MeV is described. This spectrometer makes use of the Compton and pair-production effects without eliminating them. The collimator, the crystals and the electronics have been studied in detail and are described in their final form. The problem of calibrating the apparatus is then considered; numerous graphs are given. The sensitivity of the spectrometer for different energies is determined mainly for the Compton effect group. Results of an experimental measurement of the gamma spectrum of a swimming-pool type reactor with new elements are given. (auth)

**14287** (CEA-R-3925) HIGH-RESOLUTION ALPHA SPECTROMETRY USING SEMICONDUCTOR DETECTORS; APPLICATION TO PLUTONIUM ANALYSIS. Blondel, Maurice; Legrand, Jean; Morel, Jean (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Nov 1969. 23p. (In French). Dep. CFSTI (U. S. Sales Only).

An alpha spectrometer using surface junction diodes has been developed. The junctions were of standard quality, but nevertheless enabled resolutions of 10 to 11 keV. By way of example, it was shown to be possible, using an appropriate calculation method, to analyze $^{240}Pu$ in $^{239}Pu$ with this spectrometer. (auth)

**14288** (IITRI-578-P-33-15) DEVELOPMENT OF NEUTRON SPECTROMETRY FOR CRITICAL FACILITIES. Quarterly Report No. 5, October 1-December 31, 1969. Semmler, R. A. (IIT Research Inst., Chicago, Ill.). Jan 1970. Contract AT-(11-1)-578. 5p. Dep. CFSTI.

Analysis of the proton recoil data obtained at Argonne National Laboratory was continued. Design of new wire supports for the wall-less proportional counter is in progress. (auth)

**14289** (KHFTI-69-5) DOUBLE IRON-FREE COINCIDENCE ORANGE SPECTROMETER. Rakivnenko, Yu. N.; Romanii, I. A.; Skakun, E. A.; Klyucharev, A. P.; Nakonechnyi, V. M.; Yatsenko, G. I.; Yashin, V. P. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1969. 28p. (In Russian). Dep. CFSTI (U. S. Sales Only).

A double iron-free orange spectrometer intended for the study of the decay of short-lived activities is described. The spectrometer operates under a beam of charged particles. Each of the spectrometer lenses contains 100 loops made from a copper profiled tube. The shape of the working segments of the loops was calculated so that it ensured focusing of 2 MeV electrons at a maximum line current of 600 amp. The device can be used to measure double and triple coincidences of the type ($\beta$, $\gamma$), (e, $\beta$, $\gamma$), etc. There are special openings for the input and output of the charged particle beam. The design of the spectrometer makes it possible to carry out several types of experiments. Replacement of targets or sources is made through vacuum chambers without disturbing the vacuum in the device. The operation of the $\beta$-spectrometer was checked with a $^{137}Cs$ source of diameter 10 mm. The parame-

ters of the device as determined experimentally with this source are the following: transmission per lens 16% from $4\pi$, resolution 1%. The spectrometer was placed under an accelerator beam of multicharged ions. The transportation and focusing system of the beam makes it possible to introduce into the target 96% of the extracted beam of ions for a diameter of the focusing spot of 10 mm. (JPRS)

**14290** (LA-4235) ANNOTATED BIBLIOGRAPHY OF POSSIBLE FALSE ASYMMETRIES AND THEIR CORRECTIONS IN EXPERIMENTAL MEASUREMENTS OF POLARIZATION ASYMMETRIES. Waymire, David R.; Jarmie, Nelson (Los Alamos Scientific Lab., N. Mex.). Aug 1969. Contract W-7405-eng-36. 12p. Dep. CFSTI.

An annotated list of 33 references is given concerning errors and false asymmetries in polarization and asymmetry measurements in nuclear physics. Highlights and important formulas are presented for each reference. (auth)

**14291** (PRNC-133) MEASUREMENT OF FLUORESCENT RADIATION IN VARIOUS SUBSTANCES INDUCED BY RADIOISOTOPE GAMMA RAY SOURCES. Ortiz, Eddie; de Ramfrez de Arellano, Katiuska Pagan (Puerto Rico Nuclear Center, Mayaguez). Jul 1969. Contract AT(40-1)-1833. 182p. Dep. CFSTI.

Thesis. Submitted by Katiuska Pagan de Ramirez de Arellano to Univ. of Puerto Rico, Mayaguez.

The theory of x-ray fluorescence analyses is reviewed, and a non-dispersive x-ray fluorescence spectrometer consisting of a krypton or xenon proportional counter probe and electronic equipment with a multichannel analyzer is described. Radioisotope x-ray sources were prepared using $^{57}Co$ or $^{109}Cd$ for the excitation of samples including elements ranging from Z = 19 to Z = 56. The different photon energies available from a selection of radioisotopes provide a flexibility not available with an x-ray machine. Energy selection of neighboring characteristic x-ray is performed by x-ray filter techniques. (auth)

**14292** (RISO-M-995) A TIME OF FLIGHT SPECTROMETER WITH A FOURIER CHOPPER AND A POSITION SENSITIVE DETECTOR. Kjems, Joergen (Danish Atomic Energy Commission, Risoe. Research Establishment). Nov 1969. 9p. Dep. CFSTI (U. S. Sales Only).

The design of a Time of Flight instrument with sinusoidal modulated neutron intensity is described and examples of its performance are presented. The main components are a chopper with variable frequency, a position-sensitive neutron detector, and a modified TMC 1024-channel analyzer. (W.H.K.)

**14293** (RPI-328-175) NANOSECOND TIMING FOR A LARGE LIQUID SCINTILLATOR. Hockenbury, R. W.; Moyer, W. R. (Rensselaer Polytechnic Inst., Troy, N. Y.). [1969]. 9p. Dep. CFSTI.

A description is given of the fast-slow coincidence system now used with a 1.25 meter liquid scintillation detector for keV neutron capture measurements at the Rensselaer Linac Laboratory. (auth)

**14294** (RPI-328-176) NEUTRON INELASTIC SCATTERING MEASUREMENTS WITH A GATED PHOTOMULTIPLIER. Fullwood, R. R.; Hockenbury, R. W. (Rensselaer Polytechnic Inst., Troy, N. Y.). [nd]. Contract AT(30-3)-328. 13p. Dep. CFSTI.

Neutron inelastic scattering measurements have been made on iron samples from 0.8 to 15 MeV using a gated photomultiplier mounted on a NaI crystal. The transistorized gating technique may also be applied to other scintillation detector experiments where the accelerator beam flash would otherwise limit the experiment. (auth)

**14295** STATISTICAL ERROR IN THE DETERMINATION OF PEAK PARAMETERS AS A FUNCTION OF THE CHANNEL WIDTH. Ciampi, M. (Univ., Pisa, Italy); Daddi, L. Int. J. Appl. Radiat. Isotop.; 21: 47-9(Jan 1970).

The errors encountered in determinations of peak parameters due to statistical fluctuations in channel contents were investigated. The maximum probability method (Ciampi, Daddi, D'Angelo, Nucl. Instrum. Meth. 66, 102 (1968)) and the least-squares method (Daddi, D'Angelo, Int. J. Appl. Radiat. Isotop. 19, 407 (1968)) were considered. The evaluation of errors was obtained by use of a computer program, some values being confirmed by statistical methods. (UK)

**14296** GAMMA SAMPLE VIAL FOR NUCLEAR COUNTING EQUIPMENT. (to Beckman Instruments, Inc.). British Patent 1,177,583. 14 Jan 1970. Priority date 21 Apr 1967, United States.

A gamma sample vial is described for adapting a soft beta particle scintillation detector system to measure gamma activity. (W.H.K.)

**14297** MULTILAYER SPARK CHAMBER FOR RECORDING FISSION FRAGMENTS. Ryabov, Yu. V.; Hsik, So Ton (Joint Inst. for Nuclear Research, Dubna, USSR). Prib. Tekh. Eksp.; No. 5, 47-50(Sep-Oct 1969). (In Russian).

A multilayer multiwire spark chamber of the corona type with a plane cathode and a dividing layer of ~20 $dm^2$ was prepared and studied. It was shown that the efficiency of recording fission fragments can reach 60% compared to the alpha particle recording efficiency of ~$10^{-3}$%. The chamber was used for fission cross section measurements with the JINR time-of-flight pulsed neutron spectrometer. (tr-auth)

**14298** MATHEMATICAL METHOD FOR APPROXIMATING THE DEFORMED FAST NEUTRON SPECTRA. Purica, I.; Cuculeanu, V. (Inst of Physics, Bucharest). Rev. Roum. Phys.; 14: 587-94(1969).

The method of orthogonal polynomial series which has been used in fast neutron spectroscopy by using threshold detector data is considered. A method for approximating the deformed fast neutron spectra is presented. (auth)

**14299** LIQUID HELIUM TEMPERATURE cw NMR S/N IMPROVEMENT USING A MOSFET rf AMPLIFIER. Alderman, D. W. (Cornell Univ., Ithaca, N. Y.). Rev. Sci. Instrum.; 41: 192-7(Feb 1970).

Improvement of the signal-to-noise (S/N) ratio of cw NMR spectrometers by cooling circuit components to liquid helium temperature is discussed. Criteria for design of a low temperature circuit using a twin-T bridge and MOSFET amplifier are presented. A liquid helium temperature spectrometer for operation at 16 MHz which improves S/N ratio by a factor of 5 over conventional techniques is described. (auth)

**14300** ALPHA SPECTRA FOR A PARTICULAR CASE. Vittozzi, Pio. Ass. Geofis. Ital., Atti Conv. Annu.; 15: 205-9 (Jun 1966). (In Italian).

From Proceedings of the 15th Meeting, Rome, Italy. See CONF-660672.

Some experiments on the spectra of $^{239}Pu$ alpha rays after transmission through thin layers leading to anomalous results are reported. (auth)

## *High Energy Physics Instrumentation*

*Refer also to abstract 15453.*

**14301** (SLAC-111) SLAC SPIRAL READER CONTROL SYSTEM REFERENCE MANUAL. Hu, Michael J. C. (Stanford Linear Accelerator Center, Calif.). Jan 1970. Contract AT-(04-3)-515. 93p. Dep. CFSTI.

The design and the operational aspects of SYSTEM GENIE computer control system for the spiral reader, which is a semiautomatic film digitizing machine used to measure photographs of elementary particle interactions in a hydrogen bubble chamber, are presented. (W.H.K.)

**14302** (SLAC-Trans-110) EFFECT OF ULTRASOUND ON FORMATION OF IONIZING-PARTICLE TRACKS IN A LIQUID-HYDROGEN BUBBLE CHAMBER. Akulichev, V. A.; Gavrilov, L. R.; Grebinnik, V. G.; Zhukov, V. A.; Libman, G.; Manych, A. P.; Rudin, Yu. I.; Rozenberg, L. D.; Selivanov, G. I. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated by R. Addis for Stanford Linear Accelerator Center, Calif., from report JINR-P13-4702. 15p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 24: 7649. (W.H.K.)

**14303** DETERMINATION OF THE GRAIN SIZE DISTRIBUTION OF THE PHOTOGRAPHIC NUCLEAR EMULSION BY AN ELECTRON MICROSCOPE. Apostol, A.; Nicolae, M. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 761-9 (1969).

A technique for the determination of the average grain size and the grain size distribution curve of the nuclear emulsion by the method of carbon replicas is presented. The experiments were performed using several types of nuclear emulsions such as: NIKFI $BR_2$, NIKFI $BR_3$, IFA $EN_2$, IFA $EN_3$. The statistical analysis of the presumptive errors introduced by different steps of the experimental procedure was performed. It is shown that for such a type of photographic emulsions the experimental curve of the grain size distribution fits very well a normal distribution. It is also shown that in order to establish the mean grain size and the grain distribution curve with accuracy 500-600 grains are to be measured for a given emulsion type. (auth)

**14304** PROPOSED METHOD FOR THE ELIMINATION OF THE DISTORTION OF SLOPING TRACKS IN NUCLEAR EMULSIONS. Simonin-Haudecoeur, Christiane; Schune-Boisble,

Denise; Willot-Chemel, Brigitte (Faculte des Sciences, Paris). Compt. Rend., Ser. B; 269: 586-9(29 Sep 1969). (In French).

Using the proposed method of least squares, the study and elimination of track distortion allows multiple scattering measurements and calculations to be carried out on sloping tracks. (tr-auth)

**14305** APPARATUS FOR INVESTIGATING THE PHOTOPRODUCTION OF $\pi^+$ MESONS ON HYDROGEN. Kuznetsov, V. M.; Stukov, O. I.; Repenko, E. V.; Zhankov, I. K. (Tomsk Polytechnic Inst., USSR). Prib. Tekh. Eksp., No. 5, 37-8(Sept.-Oct. 1969). (In Russian).

Equipment for recording $\pi^+$ mesons consisting of the telescope of scintillation counters and two spark chambers was described. The $\pi^+$ energy is determined in the multigap spark chamber, and the angle of ejection from the target is determined by means of a wide-gap spark chamber. (tr-auth)

**14306** CHERENKOV TOTAL ABSORPTION GAMMA SPECTROMETER. Kryshkin, V. I.; Shulik, B. V. (Tomsk Polytechnic Inst., USSR). Prib. Tekh. Eksp.; No. 5, 38-40(Sep-Oct 1969). (In Russian).

The results of calibration of a Cherenkov total absorption gamma spectrometer in the energy range 100–700 MeV are presented. The possibility of the combined operation of the gamma spectrometer and a spark chamber was investigated. The work was carried out with the SIRIUS electron synchrotron with maximum energy of 1.5 GeV. (tr-auth)

**14307** GAMMA BEAM INLET TO HYDROGEN BUBBLE CHAMBER. Bakashvili, D. L.; Nioradze, M. S.; Salukvadze, R. G.; Shvartsman, V. Sh. Prib. Tekh. Eksp.; No. 5, 44(Sep-Oct 1969). (In Russian).

The inlet channel for a beam of gamma quanta from the Erevan electron ring accelerator (ARUS) to the half-meter hydrogen–deuterium bubble chamber was described. The main features of the channel are the minimum possible wall thickness directly before the entry into the liquid hydrogen and the use of a magnetic field to decrease the charged particle background. (tr-auth)

**14308** TESTING THIN-FOIL SPARK CHAMBERS. Dukhovskoi, I. A.; Kishkurno, V. V.; Kulikov, V. V. Prib. Tekh. Eksp.; No. 5, 51(Sep-Oct 1969). (In Russian).

A method for testing the operation of a thin-foil spark chamber using a $^{90}Sr-^{90}Y$ beta source is outlined. (tr-auth)

**14309** SYSTEM FOR ACQUISITIONING INFORMATION FROM WIRE SPARK CHAMBERS. Baru, S. E.; Korshunov, Yu. V.; Kurdadze, L. M.; Onuchin, A. P.; Sidorov, V. A. (Inst. of Nuclear Physics, Novosibirsk, USSR). Prib. Tekh. Eksp.; No. 5, 51-4 (Sep-Oct 1969). (In Russian).

A system for acquisitioning information from wire spark chambers with ferrite ring memory is described. The information is recorded on standard punched tape. (tr-auth)

**14310** LOCATION OF PRIMARY COSMIC RAY PARTICLES IN PHOTOGRAPHIC EMULSION USING SPARK CHAMBERS. Goza, E. R.; Krzywdzinski, S.; Stafford, E. G. (Louisiana State Univ., Baton Rouge). Rev. Sci. Instrum.; 41: 219-25(Feb 1970).

Spark chambers have been used in conjunction with photographic emulsion to investigate the accuracy and reliability in the location of primary cosmic rays in emulsion exposed at balloon elevations. The location of these primaries in the emulsion stack has been determined using measurements made on spark chamber photographs. A sample of 118 primaries with $Z > 1$ which did not interact in the emulsion target has been used to calibrate the positions of the emulsions with respect to the spark chambers. The standard deviations of coordinate location errors in the emulsion plane and perpendicular to the emulsion plane were both 0.2 mm after calibration. The standard deviation of errors in the projected angles in the emulsions for these primaries was 0.2°. The mean and standard deviation of errors in the dip angles for these same events were 0.1 and 0.2°, respectively. A total of 191 out of 192 $Z > 1$ primaries, and 24 out of 39 $Z = 1$ target interacting primaries have been located in the emulsion without significant ambiguity. All the 63 $Z = 1$ noninteracting primaries with energies greater than 50 GeV have also been located in the emulsions without any ambiguities. Scanning efficiencies for the $Z > 1$ primaries and the $Z = 1$ noninteracting primaries were both about 100%. The scanning efficiency for the $Z = 1$ target interacting primaries was approximately 43%. The scanning time required for the location of $Z > 1$ and $Z = 1$ primaries which did not interact in the emulsion target was 2 to 3 h. Corresponding scanning times for the location of $Z > 1$ and $Z = 1$ target interacting primaries were on the order of 6 to 8 h and two to four days, respectively. (auth)

# Radiation Dosimeters

*Refer also to abstracts 13878, 13897, 14243, 14272, 14495, and 14563.*

**14311** (DUN-5938) A SELECTABLE LEVEL POCKET DOSE RATE ALARM DOSIMETER. Erickson, G. L. (Douglas United Nuclear, Inc., Richland, Wash.). 1 Jul 1969. Contract AT(45-1)-1857. 16p. Dep. CFSTI.

The design and calibration of a miniaturized pocket dose rate alarm dosimeter are described. The dosimeter uses a gamma-compensated G–M detector, and has selectable dose rate alarm points between 20 mR/hr and 50 R/hr. (W.H.K.)

**14312** (RISO-M-1203) A METHOD FOR MEASUREMENT OF TRANSIT DOSE IN EXTRACORPORAL BLOOD IRRADIATION FACILITIES BY MEANS OF THERMOLUMINESCENCE. Boetter-Jensen, Lars; Christensen, Poul (Danish Atomic Energy Commission, Risoe. Research Establishment). Dec 1969. 12p. Dep. CFSTI (U. S. Sales Only).

A thermoluminescence system is described which has been developed to determine the transit dose from extracorporeal blood irradiation devices for immuno-suppressive treatment and treatment of leukemia. Measurements have been obtained from two different blood irradiation systems supplied with Co-60 and Cs-137 gamma sources respectively. The results are discussed and compared with calculated and measured dose rates. Experiments were made with lithium borate powder suspended in demineralized water which was pumped through the irradiation facilities under the same conditions as the blood. After passing through the system the powder was filtered and washed with alcohol, and the accumulated dose was measured. The investigation covered powders with different grain sizes, and furthermore variations were made in tube diameter and liquid velocity. The method has shown a high degree of accuracy and reproducibility, which makes it possible to calibrate an irradiation system for liquids with a standard deviation of 1 to 2%. It is concluded that the applied dose-measurement method is reliable and gives a true picture of the dose absorbed by the blood. (auth)

**14313** USE OF GLASS ROD DOSIMETERS FOR CALIBRATION OF SEALED $^{90}Sr-^{90}Y$ SOURCES. Wade, L. (UT-AEC Agricultural Research Lab., Oak Ridge, Tenn.). Int. J. Appl. Radiat. Isotop.; 21: 43-4(Jan 1970).

The measured dose-rate obtained from four large sealed $^{90}Sr-^{90}Y$ sources (~1000 rad/hr) by glass rod dosimeters was compared with the calculated dose-rate and good agreement is reported. It is concluded that the use of silver-activated metaphosphate glass rod dosimeters is a relatively simple and accurate method for measurement of dose-rate in the 100-1000 rad range. (UK)

**14314** SEMI-AUTOMATIC ISODOSE TRACER FOR RADIATIONS OF HIGH ENERGY. Amalric, R.; Vigne, J. P.; Coste, G. (Lutte Contre le Cancer, Marseille). Radiaz. Alta Energ.; 8: 45-50(Apr 1969). (In French).

The increasingly frequent use of the photographic method for establishing isodose curves of radiations of high energy led to the elaboration of a semi-automatic system of recording. The apparatus consists of a densitometer, a framework the lower part of which carries the film and the upper part a metallic plate on which is placed the electrosensitive paper, a support with a tungsten point, and a detector tube head placed on the densitometer dial. Principles of functioning and performance of the apparatus are discussed. Human error is reduced to a minimum in this system and the duration of the isodose trace is four to five times shorter than that of the classical manual procedure. The space required is small and the apparatus can be easily operated by all radiotherapy personnel. The apparatus is suitable for high-energy radiotherapy and the cost is modest. Figures are presented to show isodose curves of films blackened by radiation from a $^{60}Co$ source, beta particles from a betatron, and x rays from a betatron. (H.L.W.)

**14315** EFFECT OF IMPURITIES ON THE THERMOLUMINESCENCE OF LiF SINGLE CRYSTALS. Muralidhara Rao, S.; Jolly, O. P. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 146-52(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The preparation of lithium fluoride monocrystals with known amounts of impurities including $MgF_2$, NaF, $CaF_2$, $TiO_2$, LuS, and $PbF_2$ is described, and the effects of these different impurities on the thermoluminescent light output are studied. (W.H.K.)

**14316** THERMOLUMINESCENCE RESPONSE OF LiF TO REACTOR NEUTRONS. Reedy, A. R.; Ayyangar, K.; Brownell,

G. L. (Massachusetts General Hospital, Boston). Radiat. Res.; 40: 552-62(Dec 1969).

Measurement of gamma-ray dose in a mixed neutron and gamma ray field is often made with thermoluminescent powder (TLD-700). It was observed that the apparent gamma dose measured by this method can be as much as 10 times greater than the true gamma dose depending on the radiation and the batch and history of the dosimetric powder. This apparent enhancement of response is explained in terms of the $^6Li$ content of the powder, which is estimated from the measured response to different thermal neutron fluences reported herein to be greater than stated. The thermoluminescent response of other LiF, $CaF_2$, and $Li_2B_4O_7$ powders has been measured for mixed radiation fields and the results are presented. Glow curves of TLD-700, TLD-100, and TLD-600 powders irradiated with thermal neutrons and $^{60}Co$ gamma rays are also presented. The ratio of the peak heights occurring at 255 and 195°C is greater in the case of thermal neutron-irradiated powder than that of $^{60}Co$ gamma-irradiated powder, indicating that there is relatively larger filling of 255°C traps compared to 195°C traps in the former case. With increasing thermal neutron fluence, this ratio remains constant at a value of 0.4 until a fluence of $2 \times 10^{11}$ n/cm$^2$ and then rises with neutron fluence. This trend of the peak height ratio is explained in terms of charged particle track superposition and relative filling of traps at 255 and 195°C. (auth)

**14317** DOSIMETER FOR PERMANENTLY RECORDING THE EFFECTS OF AN INTEGRATED FAST NEUTRON DOSE. Kernohan, R. H.; Sekula, S. T. (to United States Atomic Energy Commission). U. S. Patent 3,489,900. 13 Jan 1970.

A dosimeter for permanently recording the effects of an integrated fast neutron flux dose is described. Fast neutrons create defects in relatively pure niobium crystals and the remanent moment, or frozen-in magnetic flux in the crystals, produced by fast neutron bombardment can be determined from the isothermal magnetization curves. This remanent moment is proportional to the fast neutron dose from about $2 \times 10^{16}$ n/cm$^2$ to about $10^{19}$ n/cm$^2$. Thus, crystals of substantially pure niobium can permanently record the integrated fast neutron flux to which they have been exposed. No external circuitry is required and there is no problem of decay such that the final determination of the dose can be effected at any convenient time subsequent to the recording of the dose in the crystals. (AEC)

**14318** CONDUCTIMETRIC DOSIMETRY: A CALORIMETRIC METHOD FOR MEASURING HIGH-INTENSITY PULSED RADIATION. Schmidt, Klaus H.; Buck, Warren L. (Argonne National Lab., Ill.). Radiat. Res.; 40: 473-83(Dec 1969).

A calorimetric method for measuring the absorbed dose received by an aqueous solution from a 15-MeV linear accelerator, has been developed. A quartz conductivity cell with two parallel, circular platinum electrodes, filled with a 0.01 M phosphate buffer of pH 7, is placed coaxially behind a collimator confining a circular electron beam of about half the electrode diameter. When the cell receives a burst of electrons, the absorbed energy causes a temperature rise in the irradiated electrolyte which in turn results in an increase in electrical conductivity, corresponding to a temperature coefficient of about 2%/°C. The conductivity change is measured in a sensitive bridge circuit and recorded. Since, due to the short irradiation time of 2 seconds or less, the temperature rise is quasi-adiabatic, no thermal insulation is required. Doses as low as 1 kRad can be measured with a standard deviation of 3%. Errors due to radiation chemical reactions could be excluded, but a correction for the energy absorption in the platinum was necessary. The conductimetric dosimeter agreed with the Fricke dosimeter within experimental random errors. (auth)

**14319** CALORIMETRIC METHOD OF MEASURING RADIATION BY SOLUTION CONDUCTIVITY CHANGE. Schmidt, Klaus H. (to United States Atomic Energy Commission). U. S. Patent 3,489,899. 13 Jan 1970.

A method for determining the absorbed dosage in a pulse of ionizing radiation by measuring the increase in conductivity of an electrolyte solution due to absorbed radiation is described. (AEC)

**14320** DOSIMETERS FOR INDUSTRIAL IRRADIATION. Holm, N. W. (Research Establishment, Risoe, Denmark). pp 555-66 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

Dosimetry in radiation-chemical processing is usually based on "effect" dosimeters, i.e., the irradiated product itself is sampled and, by following a suitable physical or chemical parameter, one ascertains whether the desired change (i.e., effect) has been obtained. On the basis of this information the radiation conditions can then be corrected if necessary. In radiation sterilization processes, whether they concern food, pharmaceuticals or medical equipment, a specific dose or dose range is often prescribed by the authorities, and it is consequently required in such processes to control and measure the absorbed dose directly. Criteria for the selection of a dosimeter system for a given purpose are discussed, and dosimeters in actual use in industrial irradiation are described. Also, methods for calibration of routine dosimeters are considered. Some observations are made with regard to future needs. (auth)

**14321** THE MEASUREMENT OF ELECTRON AND GAMMA-RAY DOSE DISTRIBUTIONS IN VARIOUS MEDIA. McLaughlin, W. L.; Hussmann, E. K. (National Bureau of Standards, Washington, D. C.). pp 579-90 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

New radiochromic dye films and gels are proposed as simple and relatively accurate devices for imaging and determining the energy deposited locally at different depths and across interfaces of various irradiated media. Depth-dose measurements show remarkable agreement with theoretical computations in various plastics and aluminum, even near the end of the electron range, indicating that the dosimeter response is representative of the energy imparted to the medium over a wide range of electron energies. (auth)

**14322** APPLICATION OF THE ETHANOL-CHLOROBENZENE DOSIMETER TO ELECTRON BEAM DOSIMETRY: PULSED 10 MeV ELECTRONS. Dvornik, I.; Razem, D.; Baric, M. (Inst. Ruder Boskovic, Zagreb). pp 613-22 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

With gamma irradiation, the ethanol-chlorobenzene chemical dosimetric systems have shown valuable properties. They are simple to prepare and analyze, the G(HCl) values are not sensitive to normal impurities and are constant within the dose range of interest for processing. Experiments performed with 10 MeV pulsed electrons from the linear accelerator of the Research Establishment Risø, Denmark (7 microsecond pulses repeated 300 times per second, $10^9$ rad/sec in the pulse) are described. The irradiations were calibrated calorimetrically. The G(HCl) values independent of dose up to 40 Mrad are given as a function of chlorobenzene concentration. The comparison with gamma irradiations shows only insignificant differences in the G-values. Above 10 vol. % chlorobenzene the G-values are approximately constant up to 20 Mrad or more, and are to within 2% equal to those obtained for gamma rays with free access of air. The addition of 0.04% of acetone or benzene to the systems had, within the experimental error, no influence upon the G(HCl). The results show the applicability of ethanol-chlorobenzene dosimeters to the dosimetry of electron beam irradiations at dose rates as high as $10^9$ rad/sec and dosages up to 6 Mrad. (auth)

**14323** DOSE RANGE OF A FUNCTIONAL TRANSFORM SCHEME. Myazdrikov, O. A. (Leningrad Inst. of Aviation Instrument Construction). Prib. Tekh. Eksp.; No. 5, 77-9(Sep-Oct 1969). (In Russian).

The dose characteristics of a scheme with a functional transform of the currents of the ionization chamber to the pulsed signal are described. It was shown that for short bursts of quanta, the number of recorded pulses is proportional to the magnitude of the exposure dose. The accuracy of absolute measurements was not worse than ±5%. Results of the experiment were given. (tr-auth)

**14324** ACTIVATION ANALYSIS TECHNIQUES FOR DOSIMETRY AND HAZARD CONTROL WITH HIGH ENERGY RADIATIONS. Sklavinitis, L. (CEN, Saclay, France). Advan. Activ. Anal.; 1: 115-35(1969).

Activation analysis is widely used for neutron flux assessment and for the dosimetry of thermal and fast neutrons, the activity induced in a detector, usually by $(n,\gamma)$ reaction, being proportional to the flux. The same principle can also be applied in studying the hazards associated with exposure to high energy electromagnetic radiation or particles. A review of the subject is given under the following headings: Activation by high-energy radiations (definition of high-energy radiations; cross sections for high-energy reactions; use of high-energy reactions for particle fluence assessment); in-beam fluence measurements (choice of target and monitor reactions; reactions used to monitor pure particle beams; dose calculation); composite radiation fields (measurements in

mixed radiation fields; dosimetry within a phantom); calculation of absorbed dose; and possibility of use of activation detectors as particle dosimeters. Advantages and disadvantages of activation detectors are summarized. 33 references. (UK)

**14325** ADDITIVITY OF NEUTRON AND γ-RAY EXPOSURES FOR TLD DOSIMETERS. Goldstein, N. (Physics International Co., San Leandro, Calif.). Health Phys.; 18: 157-8(Feb 1970).

It had been reported by Oltman et al. (Health Phys.; 13: 918 (1967)) that, in the energy range from 0.1 to 1.0 MeV, there was a decreased γ-ray response for LiF following neutron exposure. Experiments have now been carried out to investigate the effect of 14.5 MeV neutrons on γ-irradiated luminescent detectors. Five materials were used, three samples of each being exposed to neutrons, one of which had already, and another of which later, received a 50 R $^{60}$Co–γ irradiation. No change was found in γ-ray sensitivity after neutron exposure. (UK)

**14326** LOW TEMPERATURE ANNEALING OF TLD-LiF. Harris, A. M.; Jackson, J. H. (Berkeley Nuclear Labs., Gloucester, Eng.). Health Phys.; 18: 162-4(Feb 1970).

Previous work (Harris, A. M., Jackson, J. H., Health Phys.; 15: 457(1968)) demonstrated that low temperature annealing of dosimetry grade lithium fluoride (TLD–LiF) reduced the low temperature glow peaks to a small intensity. Results are now given in graphical form from which the optimum annealing temperature for any annealing time may be derived to produce high sensitivity, low background TLD–LiF phosphors. (UK)

**14327** LINEARITY OF TLD RESPONSE CURVES. Watson, C. R. (Battelle Memorial Inst., Richland, Wash.). Health Phys.; 18: 168-9(Feb 1970).

Observations are made on a number of published works on thermoluminescence dosimetry in which the calibration data for dosimeter materials are presented as a plot of the logarithm of thermoluminescence response vs the logarithm of exposure. Authors have not always realized that a straight line on full log paper only implies linearity when it makes an angle of 45° with the logarithmic axes. It is also noted that a nonlinear response can be expected with some combinations of readout device and phosphor, and the readout device must not then be adjusted to read directly in units of exposure. (UK)

**14328** A CALORIMETER FOR ABSORBED DOSE MEASUREMENTS AT LOW DOSE RATES. Fleming, D. M. (Battelle-Memorial Inst., Richland, Wash.). Health Phys.; 18: 135-9(Feb 1970).

A twin calorimeter has been constructed and used for the measurement of absorbed dose. The calorimeter utilizes a difference in mass between the twin absorbers to provide a different thermal response. The system was tested at a dose rate of 32.3 Rad/hr with a $^{60}$Co source and the results compared to ion chamber measurements. (auth) (UK)

**14329** MEASUREMENT OF ENVIRONMENTAL RADIATION INTENSITY WITH THERMOLUMINESCENT $CaSO_4$:Dy. Mejdahe, V. (Danish Atomic Energy Commission, Risoe). Health Phys.; 18: 164-7(Feb 1970).

The properties of LiF, $CaF_2$, and $CaSO_4$ activated with Mn or Dy or Tm used as thermoluminescent phosphors in radiation dosimetry are discussed. It is concluded that for measurement of small radiation intensities over extended periods at a large number of points, in cases where tissue-equivalent response per R is not required, $CaSO_4$:Dy is an ideal phosphor. Using such phosphors environmental radiation intensities at seven archaeological excavation sites have been measured and reflect great geographical variation. Also variation with depth is noted emphasizing the importance of detailed measurement of environmental radiation in the thermoluminescence dating of ancient pottery. (UK)

## Radiometric Instruments

*Refer also to abstract 14145.*

**14330** (KFKI-34/1969) ON THE THEORY AND PRACTICE OF DENSITY CORRECTION CONCERNING NEUTRON MOISTURE MEASUREMENT. Nagy, A. Z.; Vertes, P.; Vegh, E.; Kosa, F. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). 1969. 10p. Dep. CFSTI (U. S. Sales Only).

Dry bulk density corrections for neutron radiometric moisture measurement are discussed. A double scintillation detector and a pulse-shape discriminator are used for gamma and neutron detection. Calculated and measured results are given. (W.H.K.)

**14331** NEW TYPE OF BETA SOURCE. Ansell, K. H.; Fletcher, K. E. (Radiochemical Centre, Amersham, Eng.). Int. J. Appl. Radiat. Isotop.; 21: 29-32(Jan 1970).

To extend the limited range of conventional β sources available for industrial gaging, sources using degraded β-particles were investigated. The effective absorption coefficient of the scattered radiation as a function of the scattering angle and target material was measured for $^{147}$Pm, $^{204}$Tl and $^{90}$Sr/$^{90}$Y. A prototype $^{147}$Pm source was produced for thickness gaging in the 1.5–8 mg/cm$^2$ range. (UK)

**14332** IMPROVEMENTS IN GAMMA BACKSCATTER DENSITY GAUGES FOR NON-HOMOGENEOUS SOILS. Devlin, G.; Taylor, Denis (Univ. of Strathclyde, Glasgow). Int. J. Appl. Radiat. Isotop.; 21: 32-3(Jan 1970).

It has been noted (Smith et al., A.S.T.M. Special Technical Publication No. 412, American Soc. for Testing and Materials 1968) that under conditions of non-homogeneous soils, γ-backscatter gages can give anomalous results. A method is described to overcome this difficulty using normal integral counting to investigate the density pattern throughout the soil to the maximum penetration system, followed by differential counting which scans the volume for non-uniformity as the discriminator setting is varied progressively. (UK)

**14333** γ-RADIATION ATTENUATION METHOD FOR THE DENSITY DETERMINATION OF SINTERED SPECIMENS. Avram, Magdalena (Inst. of Atomic Physics, Bucharest). Stud Cercet. Fiz.; 21: 727-30(1969). (In Rumanian).

A description of an instrument based on the absorption of γ-rays for the measurement of the density of sintered specimens placed between a radioactive source and a detection system is given. The principle consists in performing two absorption measurements, one with the specimen and the other with a standard of the same material with known density. The measurement of the transmitted radiation allows the determination of the density of a sintered specimen with a maximum relative error of 1.5%. (auth)

**14334** INVESTIGATING THE SENSITIVITY OF THE NEUTRON METHOD FOR DETERMINING THE MOISTURE CONTENT OF SOME MEDIUMS. Aleksandrov, Lyubomir; Khristov, Vasil. Izv. Fiz. Inst. Aneb, Bulg. Akad. Nauk.; 19: 255-67(1969). (In Bulgarian).

The sensitivity of the neutron method for determining the moisture content in unlimited mediums of quartz sand and iron ore was investigated with multigroup calculations of the neutron diffusion in these mediums. It is shown that there exists for each medium and each chosen geometry and situation of the detector a particular radius $r_\theta$, where the sensitivity follows a linear dependence of the moisture content. The sensitivity increases for distances where $r < r_\theta$ and decreases when $r > r_\theta$. It is greater for the perpendicular situation of the counter and decreases with the increase of the dimensions of the neutron detector. The analytic expressions for the flux $\Phi_{th}(r,w)$ and for the "radius of linearity" for an arbitrary number of groups are derived. The calculations were carried out with a standard program on an electronic computer "Minsk 22". (auth)

**14335** γ-RAY THICKNESS GAUGE FOR HOT PLATE. Murai, Shigeki; Hasegawa, Kazuto (Japan Steel and Tube Corp., Kamasaki). Nippon Kokan Giho; No. 47, 343-51(Sep 1969). (In Japanese).

The use of the γ-ray gage for the measurement of the thickness of hot steel plates has been known for a long time. Its practical application has however been difficult due to such problems as the requirements for a large quantity of radioisotope for measuring heavy thickness in plate rolling and for high stability of instrument under thermal fluctuations imposed by hot operations. As a result of various tests, the γ-ray gage was put to practical use at the Tsurumi plate mill, the Keihin Works in 1966 for the first time in Japan. Two γ-ray thickness gages are now employed at the plate mills. One is used for the measurement of center thickness and the other for edge thickness. They are both used as one of the measuring instruments for recording data for the computer control system of the plate mills and the production yield. An outline of the principles of the γ-ray thickness gages is given, and the problems and their solutions experienced during the development of the gage are discussed. (auth) (NSA of Japan)

**14336** SOURCE-DETECTOR CONFIGURATION FOR NUCLEAR BACKSCATTER GAUGE. Hannula, Fred W. (to LFE Corp.). U. S. Patent 3,493,755. 3 Feb 1970. Filed 20 Mar 1967.

The gauge is located on one side and at a substantially fixed distance from a strip of material to be measured. The source element of the gauge emits radiation by way of an elongated collimation slot towards the strip. In one embodiment the majority of

the emitted radiation passes through the strip, impinges upon a backscattering material disposed on the other side of the strip, and is returned through the strip to the gauge. The characteristics of the returned radiation and in particular its power or quantity per unit time, have a known relationship to the weight per unit area of the strip, which may then be converted to thickness on the basis of its density. The gauge source element is a radioisotope contained in an elongated capsule that emits a suitable nuclear radiation such as alpha, beta, or gamma radiation. The radiation returned to the gauge by the backscatter process is sensed by an ionization chamber. A feature of the invention is the application of a thin line source of radiation, rather than the conventional point source, so as to obtain substantially greater irradiation of the material per milli-Curie of source strength. The line source further provides a capability for measuring narrow strip samples for streak detection by orienting the line source parallel to the longitudinal dimension of the strip or measuring wide samples for average thickness values by orienting the source transverse to the strip longitudinal direction. The gauge also exhibits a configuration that enhances the signal to noise ratio of the measurement, and also includes many personnel safety features. (Offic. Gaz.).

## Miscellaneous Instruments and Components

*Refer also to abstracts 13732, 13733, 14120, 14277, 14281, 15090, 15177, 15358, 15760, 16163, 16188, 16288, and 16326.*

**14337** (ANL-7554) THE EDDY-CURRENT FLOWMETER: AN ANALYSIS GIVING PERFORMANCE CHARACTERISTICS AND PREFERRED OPERATING CONDITIONS. Wiegand, David E. (Argonne National Lab., Ill.). Aug 1969. Contract W-31-109-eng-38. 64p. Dep. CFSTI.

In the eddy-current flowmeter, motion of a fluid is measured through inductive coupling to exciting and sensing windings. An optimum excitation frequency, depending on the channel size and the fluid properties, yields maximum sensitivity. Operation in the region of the optimum frequency minimizes temperature errors and reduces velocity-profile effects. (auth)

**14338** (APDA-245) EXPERIENCE WITH UNC OXYGEN METERS IN APDA SODIUM TECHNOLOGY LOOP. Meyers, J. E.; Hunter, R. A.; Mueller, N. N.; Scott, C. C. (Atomic Power Development Associates, Inc., Detroit, Mich.). Dec 1969. Contract AT(11-1)-865. 31p. Dep. CFSTI.

In the quantitative evaluation of the UNC oxygen meter as a means of monitoring impurities in sodium, 12 of the oxygen meter electrode assemblies have been evaluated in the APDA sodium technology loop since 1965. Calibration constants determined by impurity injections ranged form −19 to −40 volts$^{-1}$. Sodium temperature coefficients varied from 0.56 to 0.04 mV/F, and ambient temperature coefficients varied from −1.16 to 0.0 mV/F. Gamma radiation caused response changes from 0 to more than 50 mV, depending on the meter. Although the oxygen meters responded immediately to changes in oxygen concentration, the total response time for oxygen meters operating more than several months was prohibitively long. (auth)

**14339** (BARC-444) AUTOMATIC DATA LOGGING SYSTEM FOR METEOROLOGICAL STUDIES IN REACTOR ENVIRONMENTS. Joshi, C. W.; Ingle, N. A.; Jathar, N. B. (Bhabha Atomic Research Centre, Bombay (India)). 1969. 38p. Dep. CFSTI (U. S. Sales Only).

A 400 ft high tower, located about half a mile from the Tarapur Atomic Power Project, is erected on which the sensors for wind speed, wind direction, temperature, etc. are located at different heights to evaluate the dispersal of effluent gases from the reactor stacks. The design and operation of an automatic data logging system for these sensors are described. The system is a wired program digital computer designed to record the data from a maximum of 248 sensors. (W.H.K.)

**14340** (CEA-CONF-1459) HOLOGRAPHIC CAMERA IN THE NANOSECOND RANGE. Buges, J. C.; Terneaud, A. (Commissariat a l'Energie Atomique, Limeil-Brevannes (France). Centre d'Etudes). 1969. 14p. (CONF-690825-2). Dep. CFSTI (U. S. Sales Only).

From Gordon Research Conference on Laser Interaction with Matter, Issaquah, Wash.

A holographic camera in the nanosecond range is described. It is able to give a ten images sequence. The frame time is about 1.5 ns and the interframe time is 1 ns. This camera will be applied to plasma diagnostics. (auth)

**14341** (CEA-R-3790) USE OF TUNNEL DIODE FOR NANOSECOND PULSE AMPLIFICATION. Chartier, Pierre (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Jan 1970. 104p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Univ. of Grenoble, France.

After a brief review of tunnel diode properties, graphic and analytic investigations of series, shunt, and compound-connected tunnel diode amplifiers are presented. A study of the noise problem is given. Also, practical realizations are described and results of measurements of their gain and noise characteristics are presented. (auth)

**14342** (CERN-69-31) VERSATILE FIVE-INPUT COINCIDENCE UNIT. Nanni, F.; Verweij, H. (European Organization for Nuclear Research, Geneva (Switzerland)). 17 Dec 1969. 21p. Dep. CFSTI (U. S. Sales Only).

A coincidence unit, type N6234, is described which will process up to five independent inputs. It has been designed to operate with standard NIM signal levels (−800 mV = "1", 0 mV = "0"). A discriminator is incorporated which provides four standardized logic outputs and one standardized complementary logic output. In addition, two time overlap outputs are available. The minimum resolving time is ≤2.0 nsec. Proper functioning is guaranteed for rates up to 100 MHz via the discriminator, and up to 200 MHz via the overlap circuit. The unit is part of the CERN-NIM compatible nucleonic instrument range. (auth)

**14343** (CONF-680520) PROCEEDINGS OF THE TENTH MODULAR SYMPOSIUM HELD AT UNITED ENGINEERING CENTER AUDITORIUM, NEW YORK, N. Y. ON 21, 22 MAY 1968. (Advisory Group on Electron Devices, New York). 366p.

Separate abstracts were prepared for three of the included papers. Two other papers previously appeared in NSA as 22: 38152 and 22: 44527. (M.O.W.)

*For abstracts of individual papers see: 14344, 15295, and 15714.*

**14344** (CONF-680520-, pp 41-6) A UNIQUE METHOD FOR HIGH POWER PULSE SHARPENING. Valencia, Vance; Morris, Dennis (Varian Associates, Palo Alto, Calif.).

Varian Associates has developed a unique method to obtain ultra fast rise and fall times which up to now have been reserved for low-power solid-state circuits. The performance listed here is a result of a company-sponsored development program to satisfy the requirements of a large electron linear accelerator system. The requirements are as follows: load voltage, 3 to 4 kilovolts; load impedance, 50 ohms; pulse length, 2.3 ns at 50% points; pulse rate, 1000 pps; and jitter, less than 2 ns, pulse to pulse. The combination of voltage, pulse length, and pulse rate is certainly an advancement of the state of art. Conventional switching techniques, such as thyratrons, nonlinear cascaded amplifiers, and isotope activated spark gaps proved ineffective in satisfying all the requirements. The solution to the problem is the unique utilization of a nonlinear distributed constant delay line which when used with conventional high-voltage fast-pulse circuits produces the required rise and fall times together with the pulse rate in excess of 1000 pps. This paper describes the practical application on nonlinear delay lines as pulse shaping devices and experimental results using this technique. Basically, the delay through a delay line is related to $\sqrt{LC}$. If L or C is a nonlinear function of voltage or current the wave front shape (rise time) can be altered accordingly and this in essence is the fundamental criteria to producing fast rise and fall times in the relatively high power region of the requirements stated above. (auth)

**14345** (EUR-4290) PANEL DISCUSSION ON FUTURE TRENDS IN PHYSICAL MEASUREMENTS AND NUCLEAR INSTRUMENTATION, ISPRA, 9 MAY 1969. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1969. 64p. (CONF-690541).

Separate abstracts were prepared for the five papers presented. (W.H.K.)

*For abstracts of individual papers see: 14346–14349 and 15716.*

**14346** (EUR-4290, pp 5-9) TOPICS IN COMPUTER AIDED CIRCUIT DESIGN. De Lotto, I. (Centro Informazioni Studi Esperienze, Milan (Italy). Bologna Univ. (Italy)).

A review on computer-aided circuit design problems is given. (61 references). (W.H.K.)

**14347** (EUR-4290, pp 11-26) CONTRASTS AND SIMILARITIES IN SYSTEMS BASED ON LARGE AND ON SMALL COMPUTERS. Lidofsky, L. J. (Stichting Instituut voor Kernphysisch Onderzoek, Amsterdam (Netherlands)).

The various phases of execution of nuclear experiments place differing requirements for computing power and for response and

execution times of the associated computing equipment. After a discussion of these points, several existing large and small scale computer systems used in broad application nuclear structure research are described. In addition to these, three other systems having particular features of interest are considered. Within the framework of the requirements mentioned, a point by point comparison is made between a generalized large scale system and one based on recently available smaller computers. It is concluded that in general and at the present time the requirements may be met with a system based on a small or a medium scale computer. (auth)

**14348** (EUR-4290, pp 27-44) CYBERNETICS IN THE LABORATORY. Soucek, B. (Institut Rudjer Boskovic, Zagreb (Yugoslavia)).

Cybernetic methods are described with examples of use in nuclear instrumentation including linear feedback shift register codes for calibration of nuclear instruments, million-channel pulse-height analysis through pseudo-random digital transformation, extraction and selection of items out of experiment, Poisson weighted sum of the n-fold convolution, treating probability density function as a pulse shape, teaching computer nuclear stochastic process theory, and the cybernetic accelerator. (W.H.K.)

**14349** (EUR-4290, pp 45-54) SOME APPLICATIONS OF THE THEORY OF STOCHASTIC PROCESSES TO NUCLEAR ELECTRONICS. Amsel, G.; Bosshard, R.; Rausch, R.; Sauce, M.; Zajde, C. (Paris Univ., Orsay (France). Ecole Normale Superieure).

The calculation of the sum of weighted autoconvolutions of spectra and the measurement of autocorrelation and crosscorrelation functions in the fast domain and its applications to nuclear electronics are discussed. (W.H.K.)

**14350** (EUR-4404(Pt.1)) IBM 1800 PROGRAMS FOR DATA PROCESSING AT THE ACCELERATORS OF THE CENTRAL BUREAU FOR NUCLEAR MEASUREMENTS. PART 1. OFF-LINE PROGRAMS FOR DATA HANDLING AND REDUCTION. Schmid, H.; Horstmann, H.; Claessens, H. (European Atomic Energy Community, Geel (Belgium). Central Nuclear Measurements Bureau). 10 Sep 1969. 244p. Dep. CFSTI (U. S. Sales Only).

A set of IBM 1800 programs for data handling and reduction at the Van de Graaff and the electron linear accelerator of the Central Bureau for Nuclear Measurements is described. Most of the data to be processed are neutron cross section data collected in time-of-flight multi-channel analyzers. These data are either buffered on magnetic tape (off-line operation) or directly transferred to the computer and stored on disk (on-line operation). The program package described contains programs for checking the analyzer data on magnetic tape, conversion of analyzer spectra (tape to card, printer, and plotter; card to tape and disk; disk to card, printer and plotter), and summing of analyzer spectra, especially for data reduction of transmission measurements. Almost all programs are written in ASSEMBLER language for the Time-Sharing Executive System (TSX). (auth)

**14351** (NYO-3906-8) ULTRASONIC THERMOMETRY IN LMFBR SYSTEMS. Progress Report Covering the Quarter Ending September 1969. Lynnworth, L. C.; Carnevale, E. H.; Papadakis, E. P.; Fam, S. S. (Panametrics, Inc., Waltham, Mass.). Oct 1969. Contract AT(30-1)-3906. 31p. Dep. CFSTI.

Progress in the development of an ultrasonic system to measure temperature in the coolant, cladding, and fuel of liquid metal-cooled fast breeder reactors is described. An anodized aluminum coil was tested at 1000°F for 1000 hours with no signal degradation. Attenuation in a 0.023 dia. by 6 inch length of remendur wire was found to be negligibly small at 1000°F. A composite thermocouple/ultrasonic temperature probe, fabricated by GE, was tested. Rhenium was calibrated to 4000°F. (W.H.K.)

**14352** (NYO-3906-9) ULTRASONIC THERMOMETRY IN LMFBR SYSTEMS. Progress Report Covering the Quarter Ending December 1969. Papadakis, E. P.; Patch, D. R.; Lynnworth, L. C.; Carnevale, E. H. (Panametrics, Inc., Waltham, Mass.). Jan 1970. Contract AT(30-1)-3906. 9p. Dep. CFSTI.

Progress in the development of an ultrasonic system to measure temperature in the coolant, cladding, and fuel of liquid metal-cooled fast breeder reactors is described. Details of the Bulk Shielding Reactor (BSR) test to determine gamma effects on a magnetostrictive transducer at high temperature are discussed, and the Oak Ridge Thermocouple (ORTC) test configuration is outlined. Also, plans for the fabrication and testing of an ultrasonic temperature sensor for an LMFBR fuel pin of the Fast Flux Test Facility (FFTF) type are indicated. (W.H.K.)

**14353** (TID-20893(Rev.3)) STANDARD NUCLEAR INSTRUMENT MODULES. Adopted by AEC Committee on Nuclear Instrument Modules. Costrell, Louis (National Bureau of Standards, Washington, D. C.). Dec 1969. 39p. Dep. GPO $0.40.

An updated and clarifying revision of the standard Nuclear Instruments Modules specifications to assure mechanical and electrical interchangeability of transistorized modular instruments is presented. (W.H.K.)

**14354** (TID-25345) A RAPID FIELD SAMPLING SYSTEM FOR TRITIUM IN ATMOSPHERIC HYDROGEN. Progress Report. Ostlund, H. Gote (Miami Univ., Fla. Rosenstiel School of Marine and Atmospheric Sciences). 1 Feb 1970. Contract AT(40-1)-3944. 6p. Dep. CFSTI.

The development of an air sampling system for tritium determination in the atmosphere is described. The sampling system is based on adding tritium-free $H_2$ gas as carrier to dried air and catalytically combusted on finely dispersed palladium metal. These water samples are collected for laboratory analysis. The sampler is designed for use in an automobile or in an aircraft with pressurized cabin. (W.H.K.)

**14355** (WCAP-3845-1) ETOG-1: A FORTRAN IV PROGRAM TO PROCESS DATA FROM THE ENDF/B FILE TO THE MUFT, GAM, AND ANISN FORMATS. Kusner, D. E.; Kellman, S. (Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.). Dec 1969. Contract AT(30-1)-3845. 128p. (ENDF-114). Dep. CFSTI.

ETOG-1, an extension of the ETOM-1 program, processes basic nuclear data in the ENDF/B format and produces the data required for the generation of MUFT, GAM-I, GAM-II, and ANISN libraries. ETOG-1 is written entirely in ASA standard FORTRAN, and is designed to be computer independent. In addition to printed results, the output includes punched cards in the format appropriate for the generation of the desired library. (auth)

**14356** MEASUREMENT OF LONGITUDINAL POLARIZATION OF BETA PARTICLES. Abhyankar, S. S.; Bhatnagar, K. G.; Bhiday, M. R. (G. S. Technological Inst., Indore, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 136-41(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The design and use of a Wein filter consisting of a crossed electric and magnetic field arrangement for polarization measurements of beta particles are described. (W.H.K.)

**14357** 1024-CHANNEL TIME ANALYZER. Vankov, Ivan; Zhuravlev, Boris; Zabiyakin, Georgi; Marinov, Marin; Uzunov, Ivan. Izv. Fiz. Inst. Aneb, Bulg. Akad. Nauk.; 19: 241-8(1969). (In Bulgarian).

A 1024 channel time analyzer with channel widths: 1, 2, 4, 8, 16, 32, 64 $\mu$s and up to 0.25 $\mu$s when using a supplementary unit is described. The opportunity for introducing an arbitrary delay for measuring with respect to the starting pulse of up to 131,072 $\mu$s exists. The channels may be divided into four groups, where the time delay may be arbitrarily chosen between the groups depending on the experiment. At the same time the required widths of the channels may be chosen. Pulse height analysis may be carried out with the aid of an amplitude coder as well as multidimensional analysis such as time-pulse height or the like. The construction of the analyzer in two separate units—coder and memory units—makes possible its use as one of the basic apparatus for the measuring center of the Institute of Physics with Nuclear Research Center. Its stability and reliability were proven in lasting exploitation. (auth)

**14358** USING THE SPARK-TYPE MASS SPECTROMETER IN METALLURGY. Vastel, J. (Thomson-CSF, Chatou, France). Mem. Sci. Rev. Met.; 66: 703-11(Oct 1969). (In French).

The SM 602 mass spectrometer is described including operating conditions, specimen preparation and conditioning, and spectrum determination. Use for semi-quantitative analysis and photometric techniques is discussed and the fields of application are described. (auth)

**14359** MULTIPURPOSE PULSE GENERATOR FOR CALIBRATION OF EQUIPMENT FOR NUCLEAR SPECTROSCOPY. Volkov, A. N.; Shtranikh, I. V.; Seregin, N. V. (Inst. of Physics, Moscow). Prib. Tekh. Eksp., No. 3, 89-92(May-June 1969). (In Russian).

A universal generator for adjustment and control of electron devices used in nuclear spectroscopy is described. The generator used the pulsation from the nuclear radiation detector for obtaining an equally probable law of distribution for output pulses according to amplitudes and time intervals. The main design of the generator, the amplitude-converter code-analog, converter code-time interval, and the system of shifting registers are given. The generator performed as a pulse generator with a precision ampli-

tude in the range from 10 mV to 10 V ± 0.5 mV; it operated as a pulse generator with linear-amplitude build up; and it functioned as a pulse generator with equally probable law of distribution of pulse amplitudes and time intervals between them. The mean pulse frequency varied from 10 Hz to 10 kHz. (tr-auth)

**14360** DEVICE FOR PRECIPITATION AND COLLECTION OF CHARGED PARTICLES FROM A GAS. (to Aktiebolaget Atomenergi). British Patent 1,176,425. 1 Jan 1970. Priority date 18 Feb 1966, Sweden.

A device for precipitation and collection of charged particles from a gas, comprising a chamber with a delivery port and a discharge port for the gas, a precipitation electrode situated in the chamber, a delivery port for a liquid to the precipitation electrode, and a discharge port for the liquid containing precipitated particles flowing from the precipitation electrode is described. The precipitation electrode comprises at least two parallel vertical or inclined wires. The upper ends of the wires are situated adjacent to the liquid delivery port and the arrangement is such that the liquid flows in the form of a film between the wires. (W.H.K.)

**14361** CURRENT REGULATOR FOR ELECTROMAGNETS. Karliner, M. M.; Levichev, B. V.; Medvedko, A. S.; Shustrov, N. V. (Inst. of Nuclear Physics, Novosibirsk, USSR). Prib. Tekh. Eksp.; No. 5, 122-4(Sep-Oct 1969). (In Russian).

The system for stabilizing the current of an electromagnet for a countercurrent electron–positron beam device is described. The constant current generator GP-5000 serves as the source of current. The operating range of the electromagnet is 1-7 kA. The error of stabilization of the given level dose not exceed (2-3) × $10^{-4}$. (tr-auth)

**14362** COMPENSATION ON THE OUTPUT OF A PULSE TIME-AMPLITUDE CONVERTOR FROM UNPAIRED INPUT SIGNALS. Baldinovskii, K. N.; Protasevich, M. Z.; Chernyavskii, A. F. (Belorussian State Univ., Minsk). Prib. Tekh. Eksp.; No. 5, 71-3(Sep-Oct 1969). (In Russian).

A circuit which operates on the basis of a method of accurate compensation of output pulses of a converter, which emerges only from the action of the start-pulse, is described. This is achieved by the introduction of an additional time-amplitude transformer and a linear summing scheme. The compensating signal has no effect on the amplitude of the exit pulse of the converter, and the time resolution is not affected by the compensation. (tr-auth)

**14363** A FOCUSING X-RAY SPECTROGRAPH FOR USE IN THE RANGE 0.5 TO 50 A. Speer, R. J. (Imperial Coll. of Science and Tech., London); Peacock, N. J.; Waller, W. A.; Osborne, P. J. H. J. Phys., E (London); 3: 143-7(Feb 1970).

A 5 m curved grating instrument is described that will record diffracted spectra photographically to a short wavelength limit below 1 Å. A 295 lines per mm NPL x-ray reflection grating is used at grazing angles of incidence of 10, 20, 40 and 60 minutes of arc. Spectra have been recorded from an x-ray tube and from the plasma focus at the Culham Laboratory. The 45 cm long instrument is capable of resolving the copper $K\alpha_1\alpha_2$ doublet at 1.540 Å and 1.544 Å in the fourth order. (auth) (UK)

**14364** TEMPERATURE MEASUREMENT IN THE HERALD REACTOR. A SPECIAL PLATINUM THERMOCOUPLE. Bignell, A. J. L.; Clark, C. R. N. Platinum Metals Rev.; 14: 11-13 (Jan 1970).

A mineral insulated platinum—13 per cent rhodium–platinum thermocouple, clad with 10 per cent rhodium–platinum and stainless steel—has been manufactured for experimental work in the Herald Reactor at Aldermaston. The clad thermocouple unit was 30 feet long and passed through 23 feet of cooling water to a reaction chamber at 1200°C. (auth) (UK)

**14365** IMPROVEMENTS IN LIQUID METAL MONITORS. Roach, Peter Francis; Davidson, Daniel Fraser (to United Kingdom Atomic Energy Authority). British Patent 1,172,246. 26 Nov 1969. Filed 29 Mar 1966.

The monitor has an orifice as part of the liquid metal flow path, which can become at least partly plugged by precipitates from the liquid metal. Means are provided at the orifice for dividing the liquid metal flow into two parts, one part passing through and the other part bypassing the orifice. Means are also provided for reentrant flow so that liquid metal prior to division of the flow is separate from but in countercurrent heat transfer relationship with that part of the flow which passes through the orifice. The monitor can be operated so that the orifice temperature is self-limiting and tends to a mean value (saturation temperature) at which for a given impurity level limit material is neither precipitated on to, nor dissolved from, a partial plug in the orifice. (UK)

**14366** METHOD OF POSITIONAL CONTROL OF ION BEAMS IN MASS SPECTROMETERS. Boyer, Robert (to Commissariat a l'Energie Atomique). British Patent 1,176,128. 1 Jan 1970. Priority date 21 Feb 1967, France.

The method and equipment for positional control of ion beams in mass spectrometers for isotopic analysis by double collection are described. A control collector collects an ion beam which is not utilized in the analysis, and an electronic assembly develops a voltage representing the imbalance of the ion currents received on the two electrodes of the control collector and applies this error signal to an amplifier which regulates the ion acceleration high-voltage supply. The isotopic analysis of uranium in the form of $UF_6$ is discussed, where the beam received by the control collector is the $UF_5^+$ beam and the $UF_3^+$ beams are used for the measurement. (W.H.K.)

**14367** URANIUM ACTIVATED BARIUM PYROPHOSPHATE PHOSPHORS. Avella, Frank J. (to General Telephone and Electronics Labs. Inc.). British Patent 1,174,380. 17 Dec 969. Priority date 16 Nov 1967, United States.

The preparation of phosphors of uranium-activated barium pyrophosphate including uranium-activated barium pyrophosphate hosts in which magnesium or cadmium has been substituted for part of the barium is described. Green light is emitted when the phosphor is exposed to radiation. (W.H.K.)

**14368** MEANS FOR DETECTION OF SURFACE CONTAMINANTS. (to Cleanometer Corp.). British Patent 1,174,595. 17 Dec 1969. Priority date 5 Nov 1965, United States.

A method of detecting contamination on a surface is described, particularly a method for detecting non-volatile organic contamination on metal and other surfaces. The method comprises applying a volatile radioactive labeled material on the surface, passing a gas over the surface to aid evaporation of the radioactive labeled material and measuring the rate at which the labeled material leaves the surface, and comparing this rate against a standard rate for evaporation of the labeled material under similar conditions from a clean surface. Selection of the appropriate radioactive labeled material is discussed, and specific examples are presented. The gas-flow vaporizer and Geiger–Mueller detector system are described. (W.H.K.)

**14369** AN ELECTRONIC SYSTEM FOR DIRECT MEASUREMENT OF THE CHARGE OF A DEVICE. De Cosnac, Bertrand; Noel, Jean-Paul (to Commissariat a l'Energie Atomique). British Patent 1,177,678. 14 Jan 1970. Priority date 2 Mar 1966, France.

An electronic system for the direct measurement of the electric charge of a capacitive device, for example, an ionization chamber, is described. The circuit comprises a high input impedance transistor; a dc voltage amplifier whose input is connected to the collector of the high input impedance transistor and whose output is connected to the gate of the transistor through a negative feedback capacitance; and a voltmeter connected to the output of the amplifier. The gate of the high input impedance transistor is connected to the device to be measured so that the voltage measured by the voltmeter is directly proportional to the charge on the device. (W.H.K.)

**14370** PROCEEDINGS OF THE SIXTH ANNUAL ALLERTON CONFERENCE ON CIRCUIT AND SYSTEM THEORY, MONTICELLO, ILLINOIS, OCTOBER 2–4, 1968. Trick, T. N.; Chien, R. T. (eds.). Urbana, Ill.; University of Illinois (1968). 914p. (CONF-681021).

Topics include pattern recognition–theory and practice, applications of optimal control, time-varying and nonlinear systems, coding, system theory, network theory, algorithms for computer-aided design and analysis, stochastic control, optimal control of discrete and distributive systems, digital systems, sensitivity, optimal control, switching theory, communications, graph theory, and stability of nonlinear systems. (W.H.K.)

**14371** PHOTOMETRIC ERROR ANALYSIS. IX. OPTIMUM USE OF PHOTOMULTIPLIERS. Young, A. T. (California Inst. of Tech., Pasadena). Appl. Opt.; 8: 2431-47(Dec 1969).

A critical study of photomultipliers leads to the following conclusions: (1) the dark current observed in tubes with alkali-antimonide cathodes at room temperature is primarily due to gas ions, not thermionic emission; (2) deviation from idealized (simple Poisson) pulse-height distributions is primarily due to secondary electron loss, particularly in venetian blind multipliers; (3) pulse-counting provides better signal-to-noise ratio than any other simple detection scheme, and is not far from optimum detection in most cases. However, dc methods can approach pulse-counting quite closely if digital readout is used. A convenient method for determining optimum discriminator levels is presented, with examples. (auth)

**14372** MERITS OF PHOTOMULTIPLIER COOLING FOR PHOTON COUNTING EXPERIMENTS. Harker, Y. D.; Masso, Jon D.; Edwards, David F. (Colorado State Univ., Fort Collins). Appl. Opt.; 8: 2563-4(Dec 1969).

An attempt is made to demonstrate that the answer to the question of merits of cooling does not depend singly upon the particular photomultiplier tube being used, but also depends on the intended photon counting rate. It is shown under what conditions a particular tube should be operated at room temperature or cooled for the largest signal-to-noise ratio. (C.E.S.)

**14373** MASS SEPARATION FOR NUCLEAR REACTION STUDIES. Klapisch, R. (Institut de Physique Nucleaire, Orsay, France. Centre de Spectometrie Nucleaire et de Spectrometrie de Masse, Orsay, France). Ann. Rev. Nucl. Sci.; 19: 33-60(1969).

The various possible ways that mass separation has been helpful in the study of complex nuclear reactions are reviewed. The review includes the aspects of mass spectrometry and isotope separators. Applications to problems of current interest are treated. (109 references). (C.E.S.)

**14374** TWO-DIMENSIONAL INTERFEROGRAMS AT 10.6 $\mu$ FOR PLASMA DIAGNOSTICS. Keilmann, F. (Institut fuer Palasmaphysik, Garching, Ger.). Rev. Sci. Instrum.; 41: 278 (Feb 1970).

A system using liquid crystals for image conversion for use in $CO_2$ laser interferometric diagnostics is described. The liquid crystals are applied in a layer 80 $\mu$ thick on a black supronyl foil 65 $\mu$ thick. Bias is obtained by the radiation from a heating wire. (C.E.S.)

**14375** A FIELD-FREQUENCY LOCKED NMR SPECTROMETER FOR KNIGHT SHIFT MEASUREMENTS. Goodrich, R. G.; Khan, H. R.; Khan, S. A.; Reynolds, J. M. (Louisiana State Univ., Baton Rouge). Rev. Sci. Instrum.; 41: 245-7(Feb 1970). (ORO-3087-36).

An NMR spectrometer is described which allows a direct plot of the Knight shift in metals to be recorded. The device uses a wide field range field-to-frequency lock unit with the output of the entire spectrometer being directly proportional to the Knight shift. Preliminary results of the field dependence of the Knight shift in aluminum obtained using the spectrometer are given. (auth)

**14376** FLUX-BALANCE SYSTEM FOR A NUCLEAR MAGNETIC RESONANCE CROSSED-COIL PROBE. Hughes, D. G.; Reed, K. (Univ. of Alberta, Edmonton). Rev. Sci. Instrum.; 41: 293-4(Feb 1970).

Problems encountered in using a crossed-coil nuclear induction system when the coupling is balanced outside the probe are eliminated by an improved version in which the quadrature balancing signal is inductively coupled to a single loop of the oscillator coil. The phase adjustment using the delay line and the amplitude adjustment using a moveable metal vane are in this case quite independent. Also the loading of the oscillator and the irradiating coils is substantially reduced. (C.E.S.)

**14377** AN IMPROVED CALIBRATION TECHNIQUE FOR CW ULTRASONIC AND NUCLEAR RESONANCE SPECTROMETERS. Smith, W. D.; Sundfors, R. K. (Washington Univ., St. Louis). Rev. Sci. Instrum.; 41: 288-90(Feb 1970).

An improved calibration method for the Bolef-Menes spectrometer involving a new calibrator circuit is described. This calibrator circuit is also usable with marginal oscillator spectrometers and other ultrasonic spectrometers. (C.E.S.)

**14378** A STABILIZED 70 Gc PLASMA INTERFEROMETER. Cummins, W. F. (Univ. of California, Livermore). Rev. Sci. Instrum.; 41: 234-7(Feb 1970).

A 70 Gc microwave interferometer for plasma density measurements has been constructed which separates the time varying amplitude and phase signal components induced by the plasma. A superheterodyne technique is used with amplitude limiting and phase detection at the 30 Mc intermediate frequency. Amplitude detection is performed prior to limiting. Phase stability is achieved by locking the local oscillator frequency to the sum or difference of the master oscillator and intermediate frequencies with an AFC loop. (auth)

## Radiation Effects on Instruments and Instrument Components

*Refer also to abstracts 14338 and 15403.*

**14379** (N-69-40757) RADIATION EFFECTS IN SILICON SOLAR CELLS. Quarterly Report. Berger, R. A.; Horiye, H.; Naber, J. A.; Passenheim, B. C. (Gulf General Atomic, Inc., San Diego, Calif.). 10 Oct 1969. Contracts NAS7-100; JPL-952387. 24p. (NASA-CR-106368; GA-9756). CFSTI.

For Jet Propulsion Lab., Pasadena, Calif.

The electron spin resonance technique has been used to study the mechanisms for the production and annealing of the divacancy (Si-G7) in lithium-diffused n-type silicon irradiated with 30-MeV electrons. The results indicate that lithium does affect divacancy production and annealing in a manner similar to the manner in which lithium affects the production and annealing of the oxygen-vacancy (Si-B1) center. Measurements of the lithium concentrations present in a lithium-diffused n-type silicon sample based on neutron activation analysis indicate that more lithium is present than as determined by resistivity measurements. (auth) (USGRDR)

**14380** (N-70-11446) DEVELOPMENT OF LITHIUM DIFFUSED RADIATION RESISTANT SOLAR CELLS. Quarterly Report. Payne, P.; Somberg, H. (Heliotek, Sylmar, Calif.). 15 Oct 1969. Contracts NAS7-100; JPL-952547. 18p. (NASA-CR-106802). CFSTI.

For Jet Propulsion Lab., Pasadena, Calif.

Boron diffusion was the principal area of investigation. This is an important phase since areas of the lithium cell investigation are dependent upon obtaining a relatively stress free boron diffusion, which is impossible with the BCl3 diffusion typically used. Experiments to investigate various material parameters were also designed. The first lot of lithium cells was fabricated and delivered to JPL and an output analysis is included. (auth) (USGRDR)

**14381** (UCRL-71574(Rev.1)) MAGNETIC PULSER FOR PAM MULTIPLEXED INSTRUMENTATION POWERED AND TIMED FROM 10 kHz 3 PHASE ac. Aaland, Kris; Pence, Glynn A. (California Univ., Livermore. Lawrence Radiation Lab.). Dec 1969. 28p. (CONF-690546-1). Dep. CFSTI.

From IEEE Conference on Applied Magnetics, Washington, D. C.

An all magnetic pulser was developed to furnish pulses to a transducer in a high radiation environment. The resulting system powers 80 transducers with a 0.3 $\mu$s wide pulse in a repetitive pattern every 50 $\mu$s, resulting in $2 \times 10^6$ amplitude modulated pulses per second rate. Power and timing are provided by a 10-kHz, 3-phase ac source. The pulse forming network, a cable, is at the same time part of the Melville compression and functions as a 30-meter long transmission line. The magnetic pulser provides reliable operation in a hazardous (radiation) environment and replaces an earlier unit which required thousands of transistors. The magnetic pulser is a further step in the evolution of design using saturable reactors. (auth)

**14382** RADIATION EFFECTS OF FISSION FRAGMENTS ON DETECTORS WITH SURFACE BARRIER LAYERS. Purica, I.; Schaechter, L.; Badanoiu, M. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 809-21(1969).

The effects of fission fragments upon detectors with barrier layer on the surface have been examined. The reverse current, the resolving power and the efficiency for a $^{239}Pu$ $\alpha$ source after various irradiation times with fission fragments have been measured. There has been located the area of sudden modifications of the efficiency which entails a second spectrum peak. The most destructive effects of fission fragments in detectors with semiconductors have been examined too. (auth)

# LIFE SCIENCES

## Biochemistry, Physiology, and Molecular Biology

*Refer also to abstracts 13732 and 13736.*

### Basic Processes

*Refer also to abstracts 14258, 14538, 14539, and 14550.*

**14383** (RLO-1750-54, pp 158-62) $^{65}$Zn AS A TOOL TO IDENTIFY STOCKS OF COHO IN THE OCEAN. Forster, William O.; Loeffel, Robert (Oregon State Univ., Corvallis. Dept. of Oceanography).

It is known that the Columbia River plume (containing $^{65}$Zn from the Hanford reactors) is carried north in the winter after entering the Pacific Ocean and south in the summer. Also, since Oregon-Washington coho (Oncorhyncus kisutch) generally enter the ocean while the plume is to the north, it was felt that sufficient $^{65}$Zn was concentrated by these coho to distinguish them from coho that were never in the Columbia River plume. Using this natural internal marker, the migration times and routes were matched with coho of known origin. The $^{65}$Zn specific activity levels for coho caught in 1967 in the northeastern Pacific ranged from 7 to 518 pCi/g ash. The 1968 catch, however, had much lower specific activity levels ranging from 0.8 to 129.8 pCi/g ash. The evidence points toward a migration route that takes juvenile Oregon-Washington coho northward along the coast into the Gulf of Alaska by the end of the first ocean summer, then southward to a point several hundred miles off the coast of Oregon and Washington, and then eastward back to the coast during their last spring in the ocean. (E.R.B.)

**14384** NEUROSPORA CRASSA GLYCOGEN PHOSPHORYLASE: CHARACTERIZATION AND KINETICS VIA A NEW RADIOCHEMICAL ASSAY FOR PHOSPHOROLYSIS. Shepherd, David; Rosenthal, Sheila; Lundblad, Gerald T.; Segel, Irwin H. (Univ. of California, Davis). Arch. Biochem. Biophys.; 135: 334-40(Dec 1969).

Purified glycogen phosphorylase ($\alpha$-1,4-glucan: orthophosphate glucosyl transferase, E. C. 2.4.1.1) from Neurospora crassa showed a specific activity of 51 units/mg protein when measured in the direction of phosphorolysis by a new radiochemical assay. Phosphorylase activity was determined by following the glycogen-dependent rate of $^{32}$P incorporation from orthophosphate-$^{32}$P into glucose-1-phosphate-$^{32}$P. This compared to 148 units/mg protein when assayed in the direction of glycogen synthesis. (C.H.)

**14385** COMPARISON OF RADIOISOTOPIC AND COLUMN CHROMATOGRAPHIC ASSAY OF SERUM THYROXINE. Kaihara, Shigekoto; Carulli, Nicola; Wagner, Henry N. Jr. (Johns Hopkins Medical Institutions, Baltimore). J. Nucl. Med.; 10: 281-3(June 1969).

Serum thyroxine was determined in 108 sera by both the column and the radioisotopic method based on competitive binding of labeled thyroxine to thyroxine-binding globulin. Radioisotopic assay showed slightly higher values than the column method did. Correlation of the two methods was satisfactory (correlation coefficient = 0.967) except for nine cases in which exogenous iodine was believed to be present. In these nine cases, the results of thyroxine assay by the radioisotopic method agreed with the clinical diagnosis. The normal range for the radioisotopic thyroxine was 5.6 to 12.6 $\mu$g of thyroxine/100 ml. Five cases showed some overlapping between the normal and abnormal range, but all other cases showed good agreement with the clinical diagnosis. (auth)

**14386** SERUM LUTEINIZING HORMONE AND PROGESTERONE CONCENTRATION DURING THE MENSTRUAL CYCLE OF THE RHESUS MONKEY. Kirton, Kenneth T.; Niswender, Gordon G.; Midgley, A. Ross Jr.; Jaffe, Robert B.; Forbes, Adelbert D. (The Upjohn Co., Kalamazoo, Mich. Univ. of Michigan, Ann Arbor). J. Clin. Endocrinol. Metab.; 30: 105-10(Jan 1970).

Concentrations of luteinizing hormone (LH) and progesterone were determined in peripheral serum samples obtained daily through four menstrual cycles in four rhesus (Macaca mulatta) monkeys. The incidence and time of ovulation were determined by laparoscopic examination. Progesterone was assayed by a competitive protein-binding method and LH by a radioimmunoassay for ovine LH which was shown to be capable of measuring simian LH. LH levels were similar during the follicular and luteal phases of the cycle, and rose sharply to approximately a 10-fold increase in concentration at midcycle in three of the four animals. All four cycles were ovulatory as determined by luteal progesterone concentrations and by laparoscopic examination. The data suggest that either the 24-hr sampling interval was not frequent enough to detect the LH peak in the fourth animal, or that ovulation occurred in the absence of an LH rise. In no case was ovulation observed to occur nor did progesterone concentration rise prior to the surge of LH. Ovulation occurred within 30 hr after the peak concentration of LH in three of the animals. Ten or 12 serum samples were obtained at 8-hr intervals near the time of ovulation in three additional animals. Plasma progesterone concentration increased slightly with the LH surge, plateaued or decreased slightly near the time of ovulation, and then increased markedly with functional development of the corpus luteum. (auth)

**14387** DETERMINATION OF VASCULAR STATUS OF PEDICLE SKIN FLAPS BY USE OF RADIOACTIVE PERTECHNETATE ($^{99m}$Tc). Tauxe, W. Newlon; Simons, John N.; Lipscomb, Paul R.; Hamamoto, Ken. (Mayo Graduate School of Medicine, Rochester, Minn.). Surg. Gynecol. Obstet.; 130: 87-93(Jan 1970).

A test was developed and evaluated for assessment of vascularity of pedicles, that has permitted grafts to be severed at the optimal time for each patient. The test was performed 107 times in 44 patients. It involves injecting a small amount of radioactive pertechnetate, $^{99m}TcO_4^-$, into a graft and following its disappearance rates before, during, and after clamping of the donor end. From the disappearance rates, percentage block is calculated, and this number has gradually become a guide to indicate the earliest safe severance time. No graft failures were observed. The shortest severance time was 10 days, and block at this time was 73%. The greatest degree of block at the time of operation was 88%. If all grafts were severed at the apparently safe 80% block value, a mean saving of 10.5 pedicle-bearing days would be effected. (auth)

**14388** ISOTOPIC METHOD FOR INSTANTANEOUS MEASUREMENTS OF EFFECTIVE RENAL BLOOD FLOW. Gagnon, John A.; Mailloux, Lionel U.; Doolittle, James E.; Teschan, Paul E. (Walter Reed Army Inst. of Research, Washington, D. C.). Amer. J. Physiol.; 218: 180-6(Jan 1970).

An externally monitored isotopic technique for instantaneous measurements of effective renal blood flow independently of urinary collections was developed in the dog. $^{131}$I-labeled orthoiodohippurate ($^{131}$I-OIH) was continuously infused by a variable infusion pump. A sodium iodide crystal detector placed over the head externally monitored the plasma concentration of $^{131}$I-OIH. The rate of isotope infusion (IV) was adjusted moment to moment to maintain a constant emission rate, i.e., to equal the concurrent rate of renal extraction. Plasma (P) and infusate (I) activity were determined separately, and effective renal blood flow (ERBF) (IV-OIH) was calculated by the formula: IV/P + (1 – Hct). These latter values were compared to simultaneous ERBF measurements obtained by urinary clearance of $^{131}$I-OIH and PAH calculated by the formula, UV/P + (1 – Hct). In 123 paired determinations of ERBF, IV-OIH averaged 175 ml/min, compared to an average UV-OIH of 171 ml/min. The urinary clearance of PAH was 194 ml/min. A second detector placed over the renal area monitored $^{131}$I activity emitted from the kidney and revealed storage and washout of clearance marker in several situations. Use of this simplified and rapid method of measuring ERBF not only obviates the need for bladder catheterization but permits the study of renal functions in a variety of acute and apparently nonsteady states that heretofore were inaccessible to conventional clearance techniques. (auth)

### Metabolism, Physiology, and Toxicology

*Refer also to abstract 14612.*

**14389** (COO-1691-5) [SOME EFFECTS OF URANYL ACETATE ON TUBULAR FUNCTION IN THE RABBIT]. Annual Progress Report. (Cincinnati Univ., Ohio). Oct. 1969. 6p. Dep. CFSTI.

Development of a method to provide some criterion for functional integrity of collecting ducts in living animals provided a basis for determining the effects of uranium on the collecting ducts. Application of the new method was made to the problem of renal toxicology of uranium in rabbits. Preliminary results indicated that at a low dose level where uranium does not cause a massive, nonspecific renal shutdown, functional damage extends beyond the proximal tubule, previously thought to be the major site of action of the uranyl ions. Studies are currently underway to determine the biochemical lesion underlying this toxic effect. (E.R.B.)

**14390** (COO-1787-8) A STUDY OF THE TRANSLOCATION OF PLUTONIUM AND AMERICIUM FROM WOUNDS. Second Technical Progress Report, December 16, 1968-December 15, 1969. Watters, R. L.; Lebel, Jacques L. (Colorado State Univ., Fort Collins. Dept. of Radiology and Radiation Biology). 20 Dec 1969. Contract AT(11-1)-1787. 28p. Dep. CFSTI.

Forty beagle dogs were implanted with air-oxidized plutonium oxide. Their excreta and selected tissues were analyzed for Pu and $^{241}$Am over a period of one year. Lymphatic transport and blood distribution were considered important in the movement of the material. The Pu/Am $\alpha$ activity ratio in blood, urine, feces, and tissue samples was used as the index for the relative metabolism of these elements in the dog. DTPA treatment showed an observable effect in urine, liver, and proximal femur tissue samples, where enhancement of the relative Pu content was seen. In general, Am enhancement was found in soft tissues and Pu enhancement was found in skeletal tissues. Data suggested the need to consider the relative metabolism of Am and Pu in interpreting in vivo measurement of Pu burdens from Am measurement. DTPA treatment had an additional effect on the relative collection of the elements in body tissues and fluids. About 10% of the lymph node burden was accumulated in the first two days. It was felt that this finding supports the industrial practice of immediately excising any wound in which measureable amounts of Pu or Am are detected. A metabolic pathway from wound site to lymph node is indicated. The probable induction of lymphosarcoma in one of the dogs was observed. (C.O.)

**14391** (RLO-1750-54, pp 148) PHOSPHORUS TURNOVER IN THE STARRY FLOUNDER (PLATICHTYS STELLATUS). Romberg, G. P.; Renfro, W. C.; Forster, W. O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Specific activity and food studies were conducted to determine the biological half-life of $^{32}$P in starry flounder (Platichtys stellatus) obtained from the Columbia River. Since phosphorus is accumulated through food, the concentration of $^{32}$P in the fish depends on both the $^{32}$P concentration in food and the turnover rate of phosphorus in the fish. Calculations using experimental data indicated a significant difference in the biological half-life of $^{32}$P in flounder less than one-year-old and those over one-year-old (7.13 days and 55.2 days, respectively). (E.R.B.)

**14392** (RLO-1750-54, pp 149) SEASONAL UPTAKE, RETENTION AND CONCENTRATION OF $^{32}$P IN JUVENILE STARRY FLOUNDER. Bolen, John; Forster, William O.; Renfro, William C. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Studies are underway to determine the existence of seasonal variations in $^{32}$P metabolism in juvenile starry flounder (Platichthys stellatus) in the Columbia River Estuary. The relation of $^{32}$P activity in prey organisms and water to those in the flounder will also be investigated. (E.R.B.)

**14393** (RLO-1750-54, pp 150-3) UPTAKE OF $^{32}$P AND $^{65}$Zn BY YOUNG CHINOOK SALMON IN THE COLUMBIA RIVER. Romberg, G. P.; Renfro, W. C. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Samples of young chinook salmon (Oncorhynchus tshawytscha) were collected over a three-week-period from the Columbia River, and the $^{32}$P specific activity and $^{65}$Zn concentration were determined. The $^{32}$P specific activity appeared to be approaching a constant value (about 16 $\mu$Ci $^{32}$P/gP) at the end of the sampling period while the $^{65}$Zn concentration continued to increase steadily. The data suggest that phosphorus turnover is faster than zinc turnover in young chinook salmon. (E.R.B.)

**14394** (RLO-1750-54, pp 154-7) DETERMINATION OF SPECIFIC ACTIVITY OF $^{65}$Zn IN TISSUES OF MYTILUS CALIFORNIANUS. Larsen, Ingvar L. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Samples of mussels (Mytilus californianus) were collected at six sampling stations along the Pacific coast at distances from 54 mi north to 357 mi south of the mouth of the Columbia River. Portions of six organ systems from each sample were analyzed by $\gamma$-ray spectrometry for $^{65}$Zn activity and by atomic absorption spectrometry for stable zinc content. A decreasing trend for $^{65}$Zn activity occurred with distance from the Columbia River southward along the coast. Values obtained from the southernmost stations could be attributed to fallout $^{65}$Zn as well as being influenced by the Columbia River. (E.R.B.)

**14395** (RLO-1750-54, pp 163-5) $^{65}$Zn DISTRIBUTION IN TISSUES OF THE PACIFIC HAKE. Naidu, J. R.; Forster, William O.; Pearcy, William G. (Oregon State Univ., Corvallis. Dept. of Oceanography).

In view of the role of the Pacific Hake (Merluccius productus) in the food chain of the marine ecosystem and the fact that it is to be exploited as a food source for man, an investigation of the $^{65}$Zn content of various tissues of the Hake was conducted to shed some light of the pathways of radionuclide transference through the aquatic food chain to man. The data from specimens collected off the Oregon coast revealed lower $^{65}$Zn levels in the tissues of the specimens collected for this study when compared with the $^{65}$Zn levels obtained in previous studies. The total zinc levels, however, were about the same, reflecting the reduction in the number of reactors at Hanford over the past few years. (E.R.B.)

**14396** (RLO-1750-54, pp 166-8) SPECIFIC ACTIVITIES OF $^{65}$Zn IN STAGHORN SCULPINS AND SAND SHRIMP IN THE COLUMBIA RIVER ESTUARY. Steinfeld, James; Renfro, William C. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Staghorn sculpin (Leptocottus armatus) and sand shrimp (Crangon franciscorum) were collected monthly from the Columbia River Estuary during 1966 and 1967 and analyzed for $^{65}$Zn specific activities. When the $^{65}$Zn activities for the two organisms were plotted for the samples obtained in chronological order, it was revealed that although the shape of the two curves was identical, the activities in shrimp were consistently two to three times higher than for the sculpin. It was also noted that the maximum activities and the minimum activities in the sculpin were similar to but several weeks later than the maxima and minima in the shrimp. This time lag may be explained by differences in the animal's trophic level, or differences in the turnover rate of zinc in each organism, or both. When the water temperatures of the Columbia River were plotted over the same period of time, the highs corresponded to the maxima for $^{65}$Zn activity in the samples and the lows to the minima for the samples. The correlations reflect the seasonal variations in metabolic activity and food intake by the organisms. (E.R.B.)

**14397** (RLO-1750-54, pp 169-71) LABORATORY ANALYSIS OF RATES OF UPTAKE AND LOSS OF $^{65}$Zn BY A MARINE, UNICELLULAR ALGA. Tomlinson, Richard D.; Renfro, W. C.; Forster, W. O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Laboratory analysis of the rates of $^{65}$Zn uptake and loss by a marine unicellular alga (Isochrysis galbana) were conducted to obtain a further understanding of environmental radionuclide transport through marine food chains that also include man. Data on $^{65}$Zn uptake by cultures of I. galbana indicate that uptake equilibrium was attained in about 23 hr and the equilibrium activity level was about 80% of the level of total activity in the solution. (E.R.B.)

**14398** (RLO-1750-54, pp 173-6) $^{65}$Zn SPECIFIC ACTIVITIES OF STARRY FLOUNDER ORGANS. Renfro, William C.; Forster, William O. (Oregon State Univ., Corvallis. Dept. of Oceanography).

The $^{65}$Zn specific activities in organs of starry flounder (Platichtys stellatus) from the Columbia River were calculated. The concept and importance of the term specific activity as a unit for measuring radioisotope content are discussed and equations used to calculate specific activities are demonstrated. Analysis of the data revealed a decreasing order of $^{65}$Zn activity in the organs of flounder as follow: liver, alimentary tract, gills, muscle-bone, and skin. The differences between the turn-over times of the various organs were calculated from organ ratios of specific activities. (E.R.B.)

**14399** (RLO-1750-54, pp 177-85) TRANSFER OF RADIONUCLIDES THROUGH A MARINE FOOD WEB. Renfro, William C. (Oregon State Univ., Corvallis. Dept. of Oceanography).

This is a continuing project designed to estimate the activities of $^{65}$Zn, $^{51}$Cr, and $^{46}$Sc held in various components of a small part of the Columbia River Estuary on a given date. Inventories are also kept of these radionuclides in different seasons to determine the magnitude of seasonal changes. The results provide additional insight into the relative importance of water, sediments, plants, and animals as reservoirs of radioactive elements. The contribution of each component of this ecosystem to the overall radionuclide content is discussed and data are presented from seasonal samples. (E.R.B.)

**14400** LYSOSOMAL UPTAKE OF ACTINIDE ELEMENTS. Taylor, D. M.; Danpure, C. J. (Inst. of Cancer Research, Sutton, Eng.). Biochem. J.; 115: 53P(Dec 1969).

It has been shown that there is lysosomal accumulation of plutonium, americium and actinium in rat liver and/or testes after injection of $^{239}$Pu, $^{241}$Am or $^{227}$Ac in soluble form. This uptake occurs in a relatively short time after injection of the metals in a soluble form and retention is prolonged. (UK)

**14401** THE UPTAKE, DISTRIBUTION, AND EXCRETION OF PROMETHIUM IN HUMANS AND THE EFFECT OF DTPA ON THESE PARAMETERS. Palmer, H. E. (Batelle-Northwest, Richland, Wash.); Nelson, I. C.; Crook, G. H. Contract AT(45-1)-1830. Health Phys.; 18: 53-61(Jan 1970).

An experiment was performed to study the uptake, retention, distribution, and excretion of promethium in humans. Six volunteers were injected with 0.1 $\mu$Ci of $^{143}PmCl_3$ and these parameters were studied for a period of one year after injection by whole body counting and excretion measurement techniques. About one-half of the injected $^{143}Pm$ remaining in the blood stream became deposited in the bone within the next 5 hr. This initial distribution between liver and bone appeared to remain unchanged for at least 1 yr. Only 10% of the injected dose was excreted within the first 20 days. The biological half life of the major portion of the dose cannot be accurately determined from this experiment but it is much greater than 1000 days. The initial uptake of $^{143}Pm$ after ingestion by two volunteers appeared to be not more than 0.001%. The effect of DTPA on the removal of $^{143}Pm$ after injection was studied in eight volunteers. The effectiveness of this chelating agent decreased rapidly with the length of time between injection of the $^{143}Pm$ and administration of the DTPA. The DTPA removed 90%, 25%, and 5% of the $^{143}Pm$ from the body when administered 30 min, 24 hr, and 80 days respectively after injection of the $^{143}Pm$. Fecal excretion of the $^{143}Pm$ is enhanced by DTPA and the total amount excreted in the feces is quite constant and is independent of the time interval between $^{143}Pm$ and DTPA injection. (auth) (UK)

**14402** THE PENETRATION OF VAPOROUS $^{131}I$ COMPOUNDS VIA RESPIRATORY ORGANS. Gorodinskii, S. M.; Eskova-Soskovets, L. S.; Rokhlin, M. I.; Sokolov, Yu. Ya.; Turkin, A. D.; Fishevskaya, E. A.; Cherednichenko, V. A.; Shatskii, S. N. (Scientific Research Inst. of Medical Radiology, Kharkov). Med. Radiol.; 12: No. 12, 23-6(Dec 1969). (In Russian).

Data are presented on the penetration of vaporous $^{131}I$ compounds via respiratory organs in man and the coefficient of retention of volatile iodine compounds in the respiratory organs is determined. The dynamics of accumulation and elimination of the isotope from the thyroid gland was also studied. (auth)

**14403** DEUTERATION OF THE MELON FLY ATTRACTANT, CUE-LURE, AND ITS EFFECT ON OLFACTORY RESPONSE AND INFRARED ABSORPTION. Doolittle, Robert E.; Beroza, Morton; Keiser, Irving; Schneider, Esther L. (Dept. of Agriculture, Beltsville, Md.). J. Insect Physiol., 14: 1697-1712(Dec. 1968).

To test a theory of olfaction based on molecular vibrations in the ir range, the effect of deuteration of an insect-attractant molecule on its biologic activity and ir spectra was compared. The structure of cuelure [4-(p-hydroxyphenyl)-2-butanone acetate], a potent attractant for the male melon fly, Dacus cucurbitae, was systematically altered by replacing atoms of hydrogen with deuterium in various parts of the molecule. The positions of substitution were established from the nuclear magnetic resonance spectra of the compounds. The deuterium substitutions did not affect the attractiveness of the compound to the male melon fly. The far-ir spectra, believed by some investigators to be related to the olfactory properties of molecules, were determined for the deuterated and undeuterated compounds. Shifts in spectral position did occur as a result of deuteration, but no relation between olfactory response and absorption in the far ir region was found. Activity and spectra of some related chemical compounds were also tested. (BBB)

**14404** EFFECT OF X-RADIATION ON THE INCORPORATION OF $^{14}C$-OROTIC ACID INTO RAPIDLY LABELED NUCLEAR AND CYTOPLASMIC RNA. Fausto, Nelson; Van Lancker, Julien L. (Brown Univ., Providence). Arch. Biochem. Biophys.; 135: 231-6(Dec 1969).

The effects of x radiation on $^{14}C$-orotic acid incorporation into nuclear and cytoplasmic rat liver RNA were studied in animals killed 24 hr after partial hepatectomy. The animals received total-body doses of 1500 R and were injected with orotic acid 10, 20, 40, and 60 min prior to sacrifice. X radiation inhibits the incorporation of orotic acid into nuclear and cytoplasmic RNA in the livers of animals injected with the precursor 10 or 20 min before they are killed. Sixty minutes after orotic acid injection no inhibition of the labeling of nuclear and cytoplasmic RNA was observed. The results suggest that x radiation retards the incorporation of $^{14}C$-orotic acid into the rapidly labeled nuclear and cytoplasmic RNA and that in the cytoplasm x radiation preferentially interferes with the labeling of RNA with rapid turnover. The retardation of the incorporation of $^{14}C$-orotic acid into nuclear RNA can be detected one hr after irradiation and reaches a maximum at six hr. It is possible that the primary injury produced by x radiation involves the DNA molecules which at the time of the irradiation function as template for the synthesis of rapidly labeled RNA. (auth)

**14405** MYOCARDIAL CLEARANCE FOR $^{84}Rb$ AS A MEASURE OF CARDIAC CIRCULATION. Boettcher, D.; Corsini, G.; Cowan, C.; Bing, R. J. (Wayne State Univ., Detroit). Z. Kreislaufforsch.; 58: 706-14(Jul 1969). (In German).

An improved method was reported for evaluation of cardiac circulation in humans that used $^{84}Rb$ and a coincidence counting system. The theoretical basis and mathematical relations necessary for estimation and calculation of cardiac circulation were described and discussed. In 24 patients without coronary disease, coronary blood flow was evaluated to be an average of 237 ml/min. This was equivalent to a fractional coronary flow of 4.3%. In 24 patients with coronary artery disease the average coronary blood flow was 169 ml/min. The advantages of the coincidence counting procedures used to measure the $^{84}Rb$ were outlined. Correction factors that were used with the myocardial clearance measurements included a correction for the differing thickness of both sides of the thorax, and a coefficient that related the coincidence counts to the ratio between the geometry of the heart and a standard solution of $^{84}Rb$. The methods for determining the position, size, and form of the heart were described. (BBB)

**14406** ENDOCYTOSIS: THE DIFFERENT ENERGY REQUIREMENTS FOR THE UPTAKE OF PARTICLES BY SMALL AND LARGE VESICLES INTO PERITONEAL MACROPHAGES. Casley-Smith, J. R. (Univ. of Adelaide). J. Microscop.; 90: 15-30(Aug 1969).

The uptake of Thorotrast ($ThO_2$) and various other different-sized particles by macrophages was studied by electron microscopy. In addition to observing normal cells, cells were examined which had been inhibited by exposing them to low temperatures (4°C) and metabolic poisons. The $ThO_2$ particles were ~20 nm dia, considered to be among the smaller particles of those tested. It was found that large particles (>0.1 $\mu$m) entered the cells and were contained in large vesicles (0.1 to 5 $\mu$m). Small particles (<50 nm) such as $ThO_2$ may also have entered the cells by this process. They entered most frequently, however, by passing into small (~70 nm) vesicles. These later coalesced and their contents adhered to give a second type of large vesicle. The various inhibitors prevented the ingestion of the large particles (and of the $ThO_2$ and other small particles en masse) into large vesicles, but did not prevent their initial adsorption onto the plasma membranes. They did not prevent nearly normal numbers of small particles from entering the pre-existing small vesicles, nor their subsequent fusion into the second class of large vesicles. (BBB)

**14407** UPTAKE OF $^{65}Zn$ IN THE HUMAN PROSTATE. Barber, D. C.; Logie, N. J.; Mallard, J. R. (Aberdeen Royal Infirmary, Scotland). Brit. J. Urol.; 41: 474(Aug 1969).

The possibility of using $^{65}Zn$ in a diagnostic test for the presence or absence of abnormal tissue in the prostate gland was investigated in nine human subjects. Patients due for prostate surgery were given 20 $\mu$Ci of $^{65}ZnCl_2$ intravenously 16 hr before operation. A sample of excised tissue was, where possible, divided into normal and abnormal tissue. The activity per gram of tissue of each sample was compared with the activity injected per gram body weight. For five patients in whom normal and abnormal tissues could be positively identified (and to a large extent separated), the mean uptake of $^{65}Zn$ in normal prostatic tissue (expressed as activity/unit activity injected/g body weight) was 4.0 with a spread from 1.9 to 7.3. For the same patients the mean uptake in both benign and malignant tissues was 5.7 with a spread of 2.8 to 10.4. In all patients the activity in the abnormal tissue was greater than that in the normal tissue by at least a factor of 1.3. For the remaining patients no separation of prostatic tissue was possible. The samples consisted of a mass of abnormal tissue and mean uptake as expressed above was 9.0 with a spread from 7.5 to 10.0. With the few patients taken in this series it was not possible to ascertain if there is any difference in $^{65}Zn$ uptake between malignant and benign tissues. Because of wide range of concentration of $^{65}Zn$ in normal and abnormal tissues, it is unlikely that a single surface count in vivo would produce a clear indication of the type of abnormal tissue or even the presence of it. However, for $^{65}Zn$, which emits a 1.1-MeV $\gamma$ ray, a scanning procedure should be possible which avoids the difficulty of interpreting a single surface count, makes it more possible to remove body background and bladder contributions, and makes possible an estimate of the size and shape of the abnormal tissue present. (BBB)

**14408** $^{67}Ga$ LOCALIZATION IN RAT AND MOUSE TUMORS. Hayes, R. L.; Nelson, B.; Swartzendruber, D. C.; Carlton, J. E.; Byrd, B. L. (Oak Ridge Associated Universities, Tenn.). Science; 167: 289-90(16 Jan 1970).

Various nonosseous tumors in mice and rats concentrate $^{67}Ga$-ESR-586 preputial gland carcinoma, P-1798 lymphosarcoma, C3H/HeJ mammary tumor, AKR/J thymic lymphoma, R-3259 giant cell sarcoma, Walker-256 carcinosarcoma, and a new transplantable neoplasm of rats. This last tumor showed the greatest affinity for gallium. Viable tumor cells are mainly responsible

for uptake of $^{67}Ga$; autoradiographic studies indicate it is located chiefly in tumor cytoplasm. (auth)

**14409** A RADIOISOTOPIC METHOD FOR DETERMINING OPTIMUM NON-SURGICAL THERAPY FOR ADVANCED CANCER. I. EXPERIMENTAL DATA. White, Richard L.; Herter, Frederic P.; Mulcare, Robert J.; McCarthy, Joseph G.; Martin, Jeannette; Buckley, Kathleen (Columbia Univ., New York. Francis Delafield Hospital, New York). Ann. Surg., 168: 357-64(Sept. 1968).

From 88th Annual Session of the American Surgical Association, Boston, Mass. See CONF-680458.

Using a miniaturized Geiger-Mueller counter implanted directly into normal tissues or 3-methylcholanthrene-induced mammary tumors in female Sprague-Dawley rats, it was possible to monitor continuously $^{32}P$ concentration in these tissues under a variety of conditions. It was observed that phosphorus utilization by tumor tissue differed from normal "resting" tissues, and, more importantly, that the pattern of phosphorus incorporation reflected accurately and rapidly the growth activity of the tumor. Retention of $^{32}P$ by tumor at a high level correlated with continuing rapid growth activity; rapid loss of $^{32}P$, however, under the challenge of exogenous hormone or confinement, heralded tumor regression or "stabilization." It is suggested that this in vivo technique for determining changing patterns of tumor growth may have clinical importance in the selection of optimum non-surgical therapy for advanced neoplasms. (auth)

**14410** A RADIOISOTOPIC METHOD FOR DETERMINING OPTIMUM NON-SURGICAL THERAPY FOR ADVANCED CANCER. II. CLINICAL EXPERIENCE. Herter, Frederic P.; Mulcare, Robert J.; McCarthy, Joseph G.; Gump, Frank E.; Ukai, Mitsu; Buckley, Kathleen; Wheeler, Brook (Columbia Univ., New York. Francis Delafield Hospital, New York. Presbyterian Hospital, New York). Ann. Surg., 168: 365-73(Sept. 1968).

From 88th Annual Session of the American Surgical Association, Boston, Mass. See CONF-680458.

Miniaturized Geiger-Mueller counters have been implanted into superficial tumors of hepatic metastases of 47 patients with advanced, inoperable cancer. The pattern of radio-phosphorus incorporation and release from these tumors has then been monitored continuously. Changes in this pattern brought about by the administration of hormones or chemotherapeutic drugs have been observed for possible correlation with clinical tumor responsiveness to that particular agent. Of 29 completely studied patients, eight demonstrated rapid $^{32}P$ loss from tumor following hormone or drug administration; all eight tumors subsequently regressed clinically on sustained treatment with the tested drug. Twenty-one tumors exhibited a pattern of $^{32}P$ retention after hormone or drug testing; 20 continued to grow in uninterrupted fashion subsequently, and one regressed 20% in size. With this one exception, the correlation between the $^{32}P$ test forecast and the subsequent clinical behavior of the tumor was absolute. The clinical data presented in this report suggest that the technique of in vivo monitoring of tumor phosphorus concentration may play a useful role in the selection of therapy for inoperable cancers. (auth)

**14411** EFFECT OF VERATRIDINE ON SODIUM-SENSITIVE RADIOCALCIUM UPTAKE IN FROG SARTORIUS MUSCLE. Johnson, Philip Neal. Philadelphia; Univ. of Pennsylvania (1968). 176p.

Thesis.

Calcium-45 experiments were performed according to procedures developed in the laboratory of Shanes and Bianchi. $^{45}Ca$ desaturation curves were constructed after washing out muscles exposed to $^{45}Ca$ media; from these, $^{45}Ca$ uptake components were calculated. Desaturations were performed in either specially designed units permitting continuous recirculation of oxygenated media around the tissue, or in test tubes (TT) containing the washout media, the tissue being moved from TT to TT at appropriate time intervals. Electrical and mechanical muscle activity was recorded on the Tektronix 502 dual beam oscilloscope and on a Schwarzer oscilloscript recorder; determination of $^{45}Ca$ activity from washout collections and tissue samples was measured by a Picker low background gas flow counter or a Packard Tri-Carb liquid scintillation counter. Veratridine potentiated the contracture tension height, and the rate and magnitude of membrane depolarization of sartorious muscles depolarized by 10, 20, 32 and 80 mM $K^+$; choline substitution for $Na^+$ abolished the veratridine-enhanced $K^+$ contractures. Tetrodotoxin (TTX) abolished the potentiated magnitude of $K^+$ depolarization but not the rate. Veratridine enhanced 20 mM $K^+$ contractures after TTX had abolished electrical excitability. In normal R, veratridine caused a decrease in muscle total $^{45}Ca$ uptake. As the $Ca^{++}$ concentration was reduced from 1.0 to 0.2 to 0.01 mM, the magnitude of the decreased $^{45}Ca$ uptake became smaller; at 0.01 mM $Ca^{++}$, veratridine no longer decreased uptake. When choline replaced $Na^+$, veratridine caused a decreased uptake at 0.01, but not at 0.2 or 1.0 mM $Ca^{++}$. In normal R, veratridine enhanced $^{45}Ca$ uptake into the slow component (SC) when muscles were depolarized by 10 or 20 mM, but not by 1.6 or 80 mM $K^+$. TTX reduced but did not abolish the enhanced uptake at 20 mM $K^+$. Enhanced SC uptake was similarly observed when $Na^+$ was replaced by lithium ($Li^+$) or hydrazine, but not when guanidine or choline were substituted for $Na^+$. Total $^{45}Ca$ uptake in the depolarization series was decreased by veratridine only in $Na^+$ R. Experiments with germine diacetate revealed effects similar to those with veratridine on total $^{45}Ca$ uptake; no enhanced SC $^{45}Ca$ uptake was observed, however. There appear to be two types of $Ca^{++}$ binding sites in muscle membrane which are affected by veratridine. The first of these sites appears to be $Na^+$-specific, veratridine (and germine) enhancing the ability of $Na^+$ to displace $Ca^{++}$ from these sites. The second site is of limited capacity (ca. 30 m$\mu$ moles/gm); the veratridine effect at this site is manifest as an enhanced translocation of $Ca^{++}$ into the SC when the muscle is depolarized in the presence of $Na^+$, $Li^+$ or hydrazine. When guanidine or choline replace $Na^+$, the veratridine effect is not longer observed (guanidine reduces $^{45}Ca$ uptake parameters; choline increases these parameters, and veratridine-enhancement of SC uptake is not observed). The relationship between the veratridine effect on SC $^{45}Ca$ uptake and the enhanced ability of $Na^+$ to displace $Ca^{++}$ is discussed with respect to excitability and excitation-contraction coupling in skeletal muscle. (Diss. Abstr.)

**14412** DISTRIBUTION OF VARIOUS RADIOISOTOPES IN THE PINE SEEDLINGS. Makhonina, G. I. Tr. Inst. Ekol. Rast. Zhivotn.; No. 61, 58-60(1968). (In Russian).

The distribution of $^{60}Co$, $^{65}Zn$, $^{90}Sr$, $^{106}Ru$, $^{115}Cd$, $^{137}Cs$, $^{144}Ce$, and $^{203}Hg$ in pine seedlings was studied in order to determine the concentration of these isotopes in various organs of the plant. The results showed that the higher relative uptake of $^{90}Sr$, $^{65}Zn$, and $^{60}Co$ occurred in the stems and needles of the plant, while the uptake of $^{106}Ru$, $^{115}Cd$, $^{144}Ce$, $^{137}Cs$, and $^{203}Hg$ was higher in the roots than in the surface parts of the plant. (R.V.J.)

## Radiation Effects

*Refer also to abstracts 14467, 14557, 14634, and 14638.*

**14413** (NYO-3242-34) THE ACTION OF RADIATIONS ON SOME BIOLOGICAL MODEL SYSTEMS. Technical Progress Report, August 15, 1968-September 12, 1969 and Summary, 1966-1969. Stein, Gabriel (Hebrew Univ., Jerusalem (Israel). Dept. of Physical Chemistry). Contract AT(30-1)-3242. 21p. Dep. CFSTI.

The role of excited states and excitation processes in the effects of ionizing radiation on biological aqueous model systems was studied. Using an aqueous solution of sodium salicylate as the model system, a study was made of the theoretical treatment of light emission under ionizing radiation. Comparisons were made between fluorescence induced by ultraviolet radiation and that induced by ionizing radiation. An experimental and theoretical nuclear magnetic resonance study of the sodium salicylate aqueous system was undertaken to substantiate the assumption of dimerization. The effects of steady state x irradiation of light emission were investigated. Effects of ionizing radiation on excitation processes in organic systems were studied using isomerization of stilbene in solvents such as benzene as an indicator of excited state formation. Studies on the role of free radicals in the radiation chemistry of biochemical and biological model systems included a detailed investigation of the specific mechanisms involved in the action of hydrogen atoms. Other studies were conducted on effects of ionizing radiation on gel systems. (H.L.W.)

**14414** (ORO-3630-8) PHOTOREPAIR OF UV DAMAGE TO DNA: STUDIES WITH THE DNA-PHOTOREACTIVATING ENZYME. Progress Report. Werbin, Harold (Texas Univ., Dallas). 2 Jan 1970. Contract AT(40-1)-3630. 25p. Dep. CFSTI.

The method of enzyme bioassay is described; it is based on increased capacity of uv-irradiated Hemophilus influenzae transforming DNA to transform competent cells after its incubation with active extracts in visible light. Methods for protein and DNA determinations, chromatographic adsorbents, concentration of enzyme solutions, and electrophoretic separation are described. Five-day old cells of the blue-green alga, Anacystis nidulans, were harvested by centrifugation for preparation of crude extract. The purification steps disclosed a 3,760-fold purification over the original extract with 10% recovery of activity. Analytical disc acrylamide gel electrophoresis revealed the presence of several protein bands. The following properties of the purified enzyme are discussed: ultraviolet absorption spectrum, enzyme stability, and molecular weight by gel filtration. The data showed that although the DNA-photoreactivating enzyme from Anacystis nidulans

was purified extensively, it still retained considerable activity. (H.L.W.)

**14415** MODIFICATIONS INDUCED BY RADIATION IN ENZYMATIC ACTIVITY. LEUCINE AMINO PEPTIDASE IN THE SERUM OF 50 PATIENTS AFTER EXPOSURE TO RADIOTHERAPY. Morganti, Mario (Ospedali ed Ospizi, Lucca, Italy). Radiaz. Alta Energ.; 8: 51-71(Apr 1969). (In Italian).

After a short reference to the change on the cytoplasmic ultrastructures induced by ionizing radiation and after a rapid review of literature concerning the enzymatic changes of blood serum caused by ionizing radiation, the enzymatic rates of LAP (leucine aminopeptidase) in 50 patients exposed to radiant treatment are presented. The determinations were made before, during, and after treatment. The results were analyzed subdividing the patients in accordance with age, kind of treatment deep x-ray therapy of $^{60}$Co $\gamma$ therapy), irradiated corporeal volume, and dose of irradiation. The data show that the behaviour of the LAP depends on dose, irradiated corporeal volume, and age of the patient. The kind of treatment is of no significance. (auth)

**14416** THYMINE-DIMER AND ACTION-SPECTRUM EVIDENCE FOR INDIRECT PHOTOREACTIVATION IN ESCHERICHIA COLI. Jagger, John; Stafford, R. S.; Snow, Jeanne M. (Univ. of Texas, Dallas). Photochem. Photobiol.; 10: 383-95 (Dec 1969).

Cells of Escherichia coli B and B phr$^-$ were labeled with tritiated thymidine, exposed to inactivating ultraviolet radiation at 254 nm, given photoreactivation (PR) treatment immediately thereafter, and then immediately hydrolyzed and assayed for thymine-containing dimers. It was found that PR treatment of strain B phr$^-$ does not split thymine dimers and the amount of splitting of thymine dimers in strain B at 334 nm is only 45% of the amount of splitting observed at 405 nm for the same amount of biological PR. These findings show that all of the PR in E. coli B phr$^-$, and part of the PR at 334 nm in E. coli B, is indirect (does not use PR enzyme) and is not due to thymine-dimer splitting. Action spectra for PR in Escherichia coli strains $B_{s-1}$ and B/r were obtained. At wavelengths below 366 nm (the indirect PR region), PR is relatively much more efficient in strain B/r in logarithmic phase than in strain B/r in stationary phase or in strain $B_{s-1}$. This is consistent with the expectation that indirect PR would not be exhibited by strains, such as $B_{s-1}$, that lack dark-repair ability, or by certain strains in the stationary phase, such as B/r, which, upon plating, have a "built-in" growth delay that can permit optimal dark repair, but indirect PR would be exhibited by intermediate cases, such as in strain B (which is less resistant to uv than strain B/r) or in strain B/r in logarithmic phase. These findings support the hypothesis that indirect PR results from enhancement of dark repair. (auth) (UK)

**14417** UTILITY OF URINARY TOTAL GONADOTROPHINS EXCRETION DETERMINATION AFTER ACUTE IRRADIATIONS BY PENETRATING RAYS. Popescu, H. I.; Klepsch, Iulia; Lancranjan, Ioana (Inst. of Hygiene, Bucharest. Inst. of Endocrinology, Bucharest). Radiat. Res.; 40: 544-51(Dec 1969).

Attention is directed to the increase of the values of urinary total gonadotrophins in eight subjects professionally exposed to ionizing radiations, who have suffered mild acute irradiations with gamma rays. The lower limits of the values of acutely irradiated subjects' total gonadotrophins, followed dynamically, are, at the first determinations, from four to over eight times greater than the upper limit of controls' values, after a variable lapse of time these having a tendency to return to normal limits. The importance of the determination of total gonadotrophins for the diagnosis of acute irradiation is emphasized by comparison with other laboratory tests done on the same subjects. (auth)

**14418** EFFECT OF X-RAYS AND $^{60}$Co GAMMA RAYS ON THE LIVER ENZYME SYSTEM RESPONSIBLE FOR FATTY ACID SYNTHESIS. Catravas, G. N. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Radiat. Res.; 40: 512-19(Dec 1969).

The effects of in vivo exposure to x-rays and $^{60}$Co gamma rays on the fatty acid synthesizing liver enzyme system were studied. Both fed and fasted young female Sprague-Dawley rats were utilized in these studies. All irradiated animals received a single whole-body exposure of 1200 R at 20 R/min. The irradiated animals as well as sham-irradiated controls were sacrificed at predetermined times after exposure, and cell-free liver homogenates that contained the enzyme system under investigation were prepared. It was found that the activity of the liver enzyme system responsible for the biosynthesis of fatty acids is greatly stimulated by x or $^{60}$Co gamma rays, and that the cytoplasmic soluble enzymes are affected by radiation to a much greater extent than the mitochondrial enzymes. Blood glucose determinations were carried out in irradiated and control rats as well as in rats which were made alloxan diabetic. The results indicate that the enhancement of enzyme activity observed is not caused by an increase in the blood glucose level of the animal as a result of exposure to radiation but to some other factor the nature of which has not yet been elucidated. (auth)

**14419** EFFECT OF IONIZING RADIATION ON THE HEMOGLOBIN STRUCTURE IN RATS. Sukhomlinov, B. F.; Makovets'kii, M. I. (Lvov State Univ.). Ukr. Biokhim. Zh.; 41: 536-40 (1969). (In Ukrainian).

The effect of ionizing radiation on a molecule of rat hemoglobin in different periods of radiation illness caused by x radiation at a dose of 800 R was studied. The amino acid composition and trypsin activity were investigated to study the disturbances in the hemoglobin structure. The results of the experiments show essential changes in the primary structure of a globin component of hemoglobin which was manifested in a quantitative change of its amino acid composition as well as in appearance of new peptide fragments in trypsin hydrolyzates of hemoglobin. (auth)

**14420** METABOLIC RATE OF SIALIC ACIDS IN THE TISSUES OF IRRADIATED ORGANISM. Malashevich, E. V.; Fomichenko, K. V. (Inst. of Physiology, Minsk). Dokl. Akad. Nauk BSSR; 13: 1039-40(Nov 1969). (In Russian).

Measurements of sialic acid content in the brain, liver, heart, and blood serum of rats 1, 2, 3 hr and 1, 3, 7, 15, and 30 days following exposure to ionizing radiation showed that x-irradiation with 40 R dose induced fixed changes in the sialic acid level in the organism. (R.V.J.)

**14421** ELECTROPHORETIC INVESTIGATION OF SOLUBLE PROTEINS OF CALF SKIN WITH ULTRAVIOLET IRRADIATION. Golovach, V. M.; Ratich, I. B. (Ukrainian Research Inst. of Physiology and Biochemistry of Domestic Animals, Lvov). Ukr. Biokhim. Zh.; 41: 531-5(1969). (In Ukrainian).

The effect of uv radiation on the content of soluble proteins, as well as on percentage ratio of the protein fraction in calf skin was studied. It was established that irradiation of the animals and those with sheared places using quartz lamps for 25 min caused a decrease in the percentage of soluble proteins in skin and changes in the ratio of protein fractions, in particular a lowering of the content of prealbumins. The detected changes were approximately of the same character in the ordinary animals and those with sheared places except for the fact that in the latter they were more pronounced and observed both during irradiation and for some time after it. (auth)

**14422** MECHANISM OF REPAIR OF DNA IN BACTERIOPHAGE. II. INABILITY OF ULTRAVIOLET-SENSITIVE STRAINS OF BACTERIOPHAGE IN INDUCING AN ENZYME ACTIVITY TO EXCISE PYRIMIDINE DIMERS. Yasuda, Seiichi; Sekiguchi, Mutsuo (Kyushu Univ., Fukuoka). J. Mol. Biol.; 47: 243-55 (28 Jan 1970).

Mutants $T4v_1$ and $T4v_2$ of bacteriophage T4, having increased uv-radiosensitivity, are unable to induce an enzyme activity that excises pyrimidine dimers from uv-irradiated DNA. Bacteriophage T2, which is as sensitive to uv light as the T4v mutants, also fails to induce the activity. The results suggest that the T4-induced dimer-excising activity may be concerned with dark repair of uv-damaged DNA in vivo. Extracts of T4-infected cells are capable of inducing single-stranded interruptions specifically in uv-irradiated DNA. The process appears to be associated with the excision of dimers, since extracts of $T4v_1$-, $T4v_2$-, and T2-infected cells, which contain no dimer-excising activity, do not induce such strand interruptions. The formation of breaks in irradiated DNA by the T4-infected cell extract occurs in the presence of EDTA. The T4-induced enzyme activity acts on DNA's of varied origins. The selective release of dimers as well as the formation of breaks in irradiated DNA take place when irradiated T2 or Escherichia coli DNA is treated with the extract of T4-infected cells. This is compatible with the finding in vivo that the $v^+$ gene product enhances the survival of not only T4 but also T2 and E. coli exposed to uv radiation. (auth)

**14423** REJOINING OF SINGLE-STRAND BREAKS OF DNA IN CULTURED MAMMALIAN CELLS. Sawada, S.; Okada, S. (Univ. of Rochester, N. Y.). Contracts AT(30-1)-1286; W-7401-eng-49. Radiat. Res.; 41: 145-62(Jan 1970).

The rejoining process of x-radioinduced single-strand breaks in cultured mammalian cells was qualitatively characterized by studying the effects of various chemical, physical, and biological factors. It occurs in irradiated cells of all ages in synchronized populations but its rate is not strongly dependent upon the age of the cells. The rate of rejoining is slowed at low temperatures. The rate of rejoining is fast, as shown from failure to demonstrate single-strand breaks after irradiation of cells at a relatively low dose rate (333 rads/min). The process rejoins radioinduced

single-strand breaks, but probably not double-strand cuts. The rejoining process is different from normal DNA synthesis in S stage cells. Furthermore, the rejoining process is probably not directly involved in other known recovery processes, i.e., recovery of the Elkind-Sutton type, recovery from potential lethal damage, repair DNA synthesis, unscheduled DNA synthesis, and restitution of chromosome aberrations. The rejoining process may play an important role in joining small replicating units in normal growing nonirradiated cells. (auth)

**14424** IRRADIATION EFFECT ON WOUND HEALING IN RATS. Archer, R. R.; Greenwell, E. J.; Ware, T.; Weeks, P. M. (Univ. of Kentucky, Lexington). Radiat. Res.: 41: 104-12(Jan 1970).

Previous studies revealed that irradiation inhibited wound healing without altering total wound collagen. However, total wound collagen determinations do not accurately reflect wound activity because the wound matrix cannot be sampled exclusively. Since the majority of new collagen being formed is in the wound matrix, detection of the rate of $^{14}C$ proline hydroxylation would provide a more accurate index of nascent collagen production. The effects of local x irradiation on the rate of $^{14}C$ proline hydroxylation in healing woulds was determined. It was concluded that collagen formation as evidenced by proline hydroxylation, begins immediately after primary wounding; a progressive increase in proline hydroxylation accompanies the secondary wound phenomenon; a single dose of irradiation inhibits proline hydroxylation, the degree and duration of inhibition being dose dependent; and these studies suggest that local wound irradiation produces distant effects on proline hydroxylation. (auth)

**14425** THE EFFECTS OF ADRENOCORTICOTROPHIN HORMONE AND METYRAPONE ON THE EXCRETION OF URINARY STEROIDS BY BEAGLE DOGS BURDENED WITH $^{90}Sr$. Mitchell, Charles E.; Longwell, Bernard B. (Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.). Radiat. Res.: 41: 78-88(Jan 1970).

Urinary 17-ketogenic steroids, 17-ketosteroids, and 17-hydroxycorticosteroids were measured in a group of Beagle dogs at various times after inhalation of $^{90}SrCl_2$ aerosols. In another group of dogs, urinary 17-ketogenic steroids and 17-ketosteroids were measured in dogs 26 months after the intravenous administration of $^{90}Sr$. Adrenocorticotrophin (ACTH) and metyrapone were used in this latter group as initiators of provocative tests, as aids in assessing adrenal and hypothamic-pituitary function. A statistically significant difference was found between sexes, where female animals excreted more 17-ketogenic steroids than male animals, and male animals excreted more 17-ketosteroids than female animals. A large amount of variability occurred among dogs and among groups. No statistically significant difference in urinary steroid levels in control dogs and dogs that had received $^{90}Sr$ was noted before or after administration of ACTH or metyrapone. (auth)

**14426** EFFECTS OF HYPOPHYSECTOMY, ADRENALECTOMY, CHOLESTEROL FEEDING, AND PUROMYCIN ON THE RADIATION-INDUCED INCREASE IN HEPATIC CHOLESTEROL BIOSYNTHESIS IN RATS. Gould, R. Gordon; Kojola, V. B.; Swyryd, E. A. (Stanford Univ., Calif.). Radiat. Res.: 41: 57-69(Jan 1970).

The mechanism of the radioinduced increase in hepatic cholesterol synthesis in rats that was reported previously, was further investigated by studies on adrenalectomized, hypophysectomized, cholesterol-fed, and puromycin-treated rats. Adrenalectomy greatly decreased the in vivo rate of synthesis of cholesterol, but did not prevent the enhancement due to irradiation. Hypophysectomy also reduced the in vivo synthesis to very low levels but in this case radiation failed to produce consistent or marked increases. Irradiation of cholesterol-fed rats increased the rate of cholesterol synthesis about 5-fold, measured either in vivo or in vitro. Esterified cholesterol levels in livers of cholesterol-fed rats were rapidly reduced by irradiation. Puromycin was used to obtain an estimate of the turnover rate of the enzymes necessary for cholesterol synthesis and also to determine if synthesis of protein is required for the appearance of the radioinduced increase in cholesterol synthesis. Large doses during a 6-hr period decreased protein synthesis by 80%, but did not affect cholesterol synthesis in un-irradiated rats. Puromycin treatment of irradiated rats during 48 hr gave an apparent decrease of about 50% as compared with irradiated rats, but this effect was of borderline significance. (auth)

**14427** EFFECTS OF GAMMA RADIATION ON THE CHEMICAL AND PHYSICAL PROPERTIES OF LACTATE DEHYDROGENASE. Winstead, Jack A.; Reece, Tyron C. (School of Aerospace Medicine, Brooks Air Force Base, Texas). Radiat. Res.: 41: 125-34(Jan 1970).

Lactate dehydrogenase was irradiated with $^{60}Co$ and the chemical and physical properties determined. Degradation of some amino acids occurred, principally alanine, cysteine, methionine, serine, tryptophan, tyrosine, and valine. The sedimentation coefficient increased and the diffusion constant decreased after exposure to ionizing radiation. Both the sedimentation and molecular weight data indicated aggregation of the irradiated lactate dehydrogenase. The Michaelis constant increased for pyruvate but remained unchanged for NADH. Readily titratable sulfhydryl groups increased after irradiation, suggesting unfolding of the tertiary structure. Two moles of PCMB could react with the irradiated lactate dehydrogenase without additional loss of biological activity. It is suggested that radiation damage to lactate dehydrogenase is initiated by the breaking of bonds responsible for the tertiary structure. (auth)

**14428** THE STUDY OF IONIZING RADIATION EFFECTS ON ESCHERICHIA COLI BY DENSITY GRADIENT SEDIMENTATION. Hildebrand, C. E.; Pollard, E. C. (Pennsylvania State Univ., University Park). Biophys. J.: 9: 1312-22(Nov 1969).

Buoyant density centrifugation of intact bacterial cells in CsCl density gradient was used to separate a population of irradiated bacterial cells into two or more subpopulations. Classification of the separated populations of irradiated cells was attempted on the following bases: viability as measured by colony-forming ability, ability to synthesize DNA during postirradiation incubation, and the relative content of intact DNA per cell in each population. It was possible to separate cells that were irradiated with $^{60}Co$ $\gamma$ rays, some of which had lost an appreciable amount of their DNA by subsequent degradation. Irradiated cells were found to band mainly at two characteristic densities, one corresponding to normal unirradiated cells and the other at a considerably lower density. The region corresponding to normal density cells is the only one that contains cells which will form colonies. Cells capable of synthesizing DNA following irradiation were found mainly at the region of normal density cells with some spreading into the lower density region. Cells in the lower density region contain less DNA than normal density cells. From an analysis of the relative numbers of cells in the two regions, it is suggested that the process of DNA degradation either takes place to a considerable extent in the genome or not at all. Analysis of the data in terms of numbers of cells having intact DNA and those having degraded DNA indicated a strong correlation between DNA degradation and cell death in this strain, JG151, and suggests that DNA degradation is a major but not the only cause of cell death. (BBB)

**14429** MECHANISM OF REPAIR OF DNA IN BACTERIOPHAGE. I. EXCISION OF PYRIMIDINE DIMERS FROM ULTRAVIOLET-IRRADIATED DNA BY AN EXTRACT OF T4-INFECTED CELLS. Sekiguchi, M.; Yasuda, S.; Okubo, S.; Nakayama, H.; Shimada, K.; Takagi, Y. (Kyushu Univ., Fukuoka). J. Mol. Biol.; 47: 231-42(28 Jan 1970).

When uv-irradiated [$^{14}C$]thymine-labeled T4 DNA was incubated with an extract of T4-infected Escherichia coli, pyrimidine dimers were selectively released into the acid-soluble fraction; the rate of release of dimers was about five times greater than that for thymine. The reaction requires $Mg^{2+}$ and proceeds at pH 7 to 8 in the dark. The amount of thymine and thymine-containing dimers released from the uv-irradiated DNA into the acid-soluble fraction was determined by Dowex 1 column chromatography. Dimers lost from the DNA were almost quantitatively recovered, in the form of nucleotides but not of free bases or nucleosides, in the acid-soluble fraction. As a result of the specific release of dimers, the content of dimers in the DNA decreases progressively during the incubation. Thus the excision in vitro is similar to the reaction observed in vivo in uv-radioresistant cells. An extract of normal cells does not exhibit the preferential release of dimers even when the homologous E. coli DNA is used as substrate. Only a small amount of dimers is released into the acid-soluble fraction during the incubation of irradiated E. coli or T4 DNA with the normal cell extract. Thus the level of dimer-excising activity of normal cells, if any, must be very low compared with that of T4-infected cells. It is likely that enzyme(s) responsible for excision of dimers is induced by infection with T4. (auth)

**14430** ASCORBIC ACID CONTENT IN THE ADRENAL GLANDS OF IRRADIATED RATS UNDER CONDITIONS OF DESTRUCTION OF MACROCELLULAR NEURONES OF THE HYPOTHALAMUS. Molotkov, O. V.; Parshkov, E. M. (Obninsk Inst. of Medical Radiology, USSR). Probl. Endokrinol.; 15: No. 6, 59-62(Nov-Dec 1969). (In Russian).

The changes in the content of ascorbic acid in the adrenal glands of rats, irradiated with gamma rays in a dose of 800 R (dose rate – 50 R per sec) at various periods after a single-stage destruction of the paraventricular and supraoptic nuclei of the hypothalamus were studied. A reduction of ascorbic acid content was shown in the adrenal glands of animals decapitated one hour after the irradia-

diation. This effect was absent in rats irradiated 2 and 6 days after the operation. The content of ascorbic acid in the adrenal glands of the animals proved to fall 30 days after the destruction of the nuclei and 1 hour after the action of radiation energy. Ascorbic acid content in the adrenal glands of unoperated rats proved to return to the initial level 24 hours after the irradiation. In the adrenal glands of animals a fall of ascorbic acid concentration was noted 3 and 7 days after the operation. (auth)

**14431** INITIATION BY RNA POLYMERASE ON UV OR X-RAY DAMAGED T7 DNA. Chessin, Henry; Summers, William C. (Yale Univ., New Haven). Biochem. Biophys. Res. Commun.; 38: 40-5(6 Jan 1970).

It is possible to dissociate template activity from initiation specificity of Escherichia coli RNA polymerase. Ultraviolet damage in DNA diminishes the template activity of bihelical T7 DNA but does not result in new nonspecific initiation points. On the other hand, x-ray damage in DNA not only decreases template activity, but also increases nonspecific initiation. These results show that the quality of the template DNA is a critical consideration in studies on the initiation specificity of RNA polymerase in vitro. (auth)

**14432** EFFECT OF X-IRRADIATION ON THE ACTIVITY OF PROTEIN SYNTHESIZING SYSTEM FROM REGENERATING RAT LIVER AT EARLY PERIODS AFTER PARTIAL HEPATECTOMY. Khanson, K. P.; Komar, V. E.; Kuznetsova, A. A. (Central Research Roentgeno-Radiological Inst., Leningrad). Vop. Med. Khim.; 15: 584-8(Nov-Dec 1969). (In Russian).

Protein synthesizing activity of microsomal fraction isolated from regenerating rat liver after total irradiation of animals at a dose 1500 R was studied. The microsomal activity is stimulated by irradiation at 6 and 18 hr after partial hepatectomy, and then tends to decrease. Labeled phosphate uptake into cytoplasmatic RNA is inhibited 6 h after the operation and goes to normal level at 24 h. The ability of high-polymer RNA from regenerating rat liver to stimulate cell free protein synthesis was decreased after total x irradiation. (auth)

**14433** SODIUM METABOLISM DISTURBANCES AFTER LETHAL ABDOMINAL IRRADIATION IN THE RAT. Bouckaert, A. (Univ. of Louvain, Belg.). Atomkernenergie, 14: 440-2(Nov.-Dec. 1969).

The compartmental distribution of sodium was investigated in lethally abdomen-irradiated rats by means of kinetic analysis of tracer behavior. The results suggest the trapping of sodium into a large slowly-exchanging sodium pool as a response to the radiation injury. (auth)

**14434** CHANGES IN $^{3}$H-THYMIDINE INCORPORATION INTO HEMATOPOIETIC CELLS OF GOLDFISH DURING RECOVERY PERIOD FROM RADIATION INJURY. Etoh, Hisami (National Inst. of Radiological Sciences, Chiba, Japan). Annot. Zool. Jap.; 42: 159-65(Sep 1969).

X-irradiated goldfish, Carassius auratus, were kept at 15 or 25°C before and after irradiation and given a single intraperitoneal injection of $^{3}$H-thymidine at various post-irradiation intervals. Smear preparations of the head kidneys bearing hematopoietic tissues were made at appropriate intervals for autoradiographic studies. Incorporation of $^{3}$H-thymidine was inhibited and practically no cell-proliferation took place in the hematopoietic tissue after irradiation with 8 kR. In fish irradiated with 1 or 2 kR and kept at 25°C, recovery of DNA synthesis and mitotic activity took place within 96 hours after irradiation, while in similarly irradiated fish kept at 15°C, recovery occurred 6 or more days later. The results seem to show that recovery processes from radiation injury to the hematopoietic tissue are slowed down at the lower temperature and that the processes required a longer time to occur than in the intestinal epithelium. The present experiments appear to lend support to the previously reported view on the kinetics of recovery from sublethal radiation damage. (NSA of Japan)

**14435** RESPONSE OF HISTONE FRACTIONS TO X IRRADIATION IN CULTURED CHINESE HAMSTER CELLS. Gurley, Lawrence R.; Hardin, Julia M.; Walters, Ronald A. (Los Alamos Scientific Lab., N. Mex.). Biochem. Biophys. Res. Commun.; 38: 290-7(23 Jan 1970).

Irradiation of cultured Chinese hamster cells with 900 R x rays, resulted in dissociation of small amounts of histones from chromatin. However, during the division delay period that followed irradiation, histones reassociated with the chromatin. Histone f3 accumulated in 50% excess over nonirradiated controls during this period. This excess f3 may contribute to the death of x-irradiated cells. Part of the excess f3 deposited during the division delay period was synthesized 5 to 10 hr prior to its deposition in the chromatin and offers further evidence that there exists within the cell a nonchromatin pool of histones. (auth)

## *Immunology*

*Refer also to abstracts 14518 and 14604.*

**14436** INFLUENCE OF THE PURIFICATION OF $^{125}$I-IODINATED THYROTROPIN ON THE SENSITIVITY OF THE RADIOIMMUNOASSAY. Golstein Golaire, J.; Vanhaelst, L. (Univ. of Brussels). Int. J. Appl. Radiat. Isotop.; 21: 17-20 (Jan 1970).

After purification of $^{125}$I iodinated human thyrotropin on sephadex G-100 two labeled compounds are obtained. Their immunological behavior in the radioimmunoassay is compared and the importance of the selection of one of them as tracer for a sensitive assay is demonstrated. (auth) (UK)

**14437** THE PROBLEM OF ANTIBODY DEPRESSION BY CYTOSTATIC AND RADIOLOGICAL TREATMENT. Neidhardt, Malte (Univ. Mainz). Monatsschr. Kinderheilk.; 117: 282-4 (Apr 1969). (In German).

The immunodepressive effects of x irradiation were studied with influenza virus in rabbits, guinea pigs, and in human patients. In rabbits and guinea pigs, the irradiation was given in 20 treatments of 200 R each 5 days/week, or, when given with Endoxan, the irradiation consisted of 20 treatments of 200 R each 3 days/week. In humans with tumors, the irradiation treatment consisted of 150 to 200 R of $^{60}$Co $\gamma$ irradiation given 3 days/week. There was no significant lowering of the antibody titer in the rabbits or guinea pigs after irradiation. In man, the maximum antibody titer was delayed, and the absolute maximum value of the antibody titer was greater than the antibody titer of leukemia patients treated with methotrexate and Decortin. These results indicated that there was a considerable reserve of immunization capacity available even after irradiation. This result agreed with observations that susceptibility toward infections was not increased in patients with localized tumors as long as the leukocyte counts were not permitted to fall below 1500/mm$^{3}$. (BBB)

**14438** PROLIFERATION OF SPLEEN-DERIVED CELLS IN THYMUS OF LETHALLY IRRADIATED MICE. Tyan, Marvin L.; Cole, Leonard J. (Naval Radiological Defense Lab., San Francisco). Transplantation; 8: 751-3(Nov 1969).

It has been generally assumed that there were few or no lymphoid stem cells in thymus, lymph node, or spleen suspensions from adult mice capable of recolonizing the regenerating thymus of an irradiated host. It was thought that bone marrow served the adult mouse as the major, or perhaps as the sole, source of these cells. Results are presented from a study that indicates that the spleens of adult mice do contain at least a small number of cells capable of entry into and proliferation in an irradiated thymus. As there is no evidence that the regenerating thymus contains myeloid or erythroid activity, the assumption is made that these spleen-derived cells are in some way involved in the immune mechanism. The cells may be lymphoid precursors identical or similar to those found in bone marrow, or they may be of a type whose function has yet to be described. It is recognized, however, that this experimental model is artificial and involves tissues under the extreme and abnormal stress of regeneration following lethal irradiation. The relevance of these findings to normal physiological processes thus remains unknown. Twelve- to 14-week-old male CBA/J and CBA-T6T6 mice were used as both donors and recipients (CBA-T6T6 cells contain two distinct minute chromosomes which are readily distinguished in metaphase). The hosts received 840 rads of whole-body x radiation. The donor spleen cells were suspended in cold TC-199 (Difco), and each recipient was given approximately $150 \times 10^{6}$ viable nucleated cells i.p. shortly after irradiation. As controls, other CBA/J or CBA-T6T6 mice were given $7 \times 10^{6}$ bone marrow cells from the opposite strains, i.v. The survivors were killed 21, 26, and 29 days later, and their thymus and spleen were prepared for chromosome analysis. The thymuses were dissected carefully in an effort to eliminate contamination with mediastinal lymph nodes or peripheral blood. Only the thymus assays are reported. The results were unaffected by the host-donor combination used. In addition, 6 irradiated CBA/J mice were given $30 \times 10^{6}$ CBA-T6T6 lymph node cells and $0.5 \times 10^{6}$ CBA/J bone marrow cells i.v.; they were killed 23 days later. The regenerating thymuses of lethally irradiated mice protected with spleen cells alone contained from $1/10$ (at 21 days) to $1/3$ (at 29 days) the number of cells found in the thymuses of mice given $7 \times 10^{6}$ bone marrow cells. The mean mitotic rates were similarly but not as severely depressed. The majority of metaphase plates at 21 days, and all of those examined 26 and 29 days after irradiation, were of donor type. (C.H.)

**14439** STUDIES ON THE PASSIVE TRANSFER OF EXPERIMENTAL ALLERGIC ENCEPHALOMYELITIS. Purdy III,

Charles William. Columbia, Mo.; Univ. of Missouri (1969). 158p.

Thesis.

Inbred Lewis strain female rats were used as donors and recipients in this study of EAE. Donor rats were intradermally inoculated with 115 mg of guinea pig spinal cord tissue emulsified in Freund's complete adjuvant containing 1.4 mg (dry weight) of killed Mycobacterium tuberculosis. Lymph nodes from donor animals (immunized 9 days) were removed and processed for their lymphoid cells. A donor-recipient ratio of 1:1 was used. Recipient rats were injected intravenously and intraperitoneally with donor lymph node cells. Recipients were killed 8 days after receiving donor cells. Four experiments were designed to test the immunologic capabilities of non-irradiated and x-irradiated encephalitogen primed lymph node cells (EPC) which were injected into recipient rats. The recipient rats were either non-irradiated or x-irradiated (600 R) 24 hours prior to passive transfer of donor cells. Donor EPC were injected into x-irradiated recipients. Six of six rats developed signs of EAE within 5 to 7 days and all had typical histologic changes of EAE upon microscopic examination of the central nervous tissues. Donor EPC were irradiated in vitro with from 200 rad to 1500 rad of x-irradiation prior to their injection into nonirradiated rats. Twelve of 15 rats developed signs of EAE within 4 to 8 days after receiving irradiated cells (200 to 600 rad). Fifteen of 15 rats receiving irradiated cells (200 to 600 rad) had histologic lesions of EAE. No signs of EAE were observed in four rats injected with irradiated cells (700 rad); however, three of the four rats had histologic lesions of EAE. Nine of nine rats receiving irradiated cells (800 to 1500 rad) did not develop signs or histologic lesions of EAE. Donor EPC were x-irradiated (200 to 600 rad) and injected into previously irradiated rats. Eight of 14 rats developed signs of EAE within 5 to 7 days. Eleven of 14 rats had histologic lesions of EAE. These histologic lesions were generally confined to the meninges of the brain and spinal cord. One of four rats injected with irradiated EPC (700 rad) had lesions of EAE. Twelve irradiated recipient rats were injected with irradiated EPC (200 to 700 rad). Six of these rats were injected 3 days later with adjuvant primed lymph node cells. Seven of 12 rats developed signs of EAE within 4 to 8 days and four of the seven rats which showed signs also received adjuvant primed cells. Nine of 12 rats had histologic lesions of EAE and five of the nine rats which developed lesions also received adjuvant primed cells. The following conclusions were made: x-irradiation of the recipient had no apparent effect on the development of EAE in adoptively immunized rats. Irradiation of EPC (200 to 600 rad) did not change the observed intensity of signs or lesions of EAE in adoptively immunized non-irradiated rats. Irradiation of recipient rats and of EPC (200 to 700 rad) greatly reduced but did not eliminate the resulting histologic lesions of EAE. A second passive transfer of adjuvant primed lymph node cells 3 days after the injection of donor EPC did not change the intensity of the resulting histologic lesions. The less intense lesions of EAE were probably the result of a reduced number of non-sensitized cells, which are highly radiosensitive, reacting with the central nervous tissues of irradiated recipients of irradiated cells. Such lesions which developed were thought to be composed primarily of encephalitogen primed lymph node cells. The radioresistant encephalitogen primed lymph node cells were immunologically inactivated when irradiated with 700 to 800 rad of x-irradiation. (Disser. Abstr.)

**14440** TISSUE RESPONSE TO X-IRRADIATED TOOTH TRANSPLANTS. Fong, Chester; Berger, James (Univ. of California, San Francisco). Oral Surg., Oral Med., Oral Pathol.; 29: 275-81(Feb 1970).

Forty-three autologous and 44 allogeneic incisor transplants in rhesus monkeys were subjected to either 200 or 10,000 R of x irradiation extraorally prior to insertion. Clinical and histologic investigation from 5 weeks to 23 months postoperatively indicated progressive destruction of both autografts and allografts. The transplanted teeth were ankylosed and underwent gross internal and external resorption. The irradiated autografts reacted unlike control autografts from other experiments and indicated the need of vital tissue for successful autologous transplantation. Neither 200 nor 10,000 R of x irradiation altered the progressive destruction of the allogeneic transplants. Enhancement of tooth allotransplants through the use of x irradiation was not seen. (auth)

**14441** IMMUNIZATION OF CHICKENS WITH IRRADIATED LARVAE OF STRONGYLOIDES AVIUM. Chaia, Geraldo (Instituto Nacional de Endemias Rurais, Belo Horizonte, Brazil). Rev. Inst. Med. Trop. Sao Paulo, 11: 19-24(Jan.-Feb. 1969).

Thirty chickens were vaccinated, by subcutaneous route, with about 12,000 larvae of Strongyloides avium previously irradiated with 140 kR. Thirty days later, both vaccinated and control chickens (8) were infected with about 1,500 normal larvae. The mean numbers of worms recovered from vaccinated and nonvaccinated chickens (controls) were 6 (0.4%) and 262 (17.4%), respectively. The worms recovered from the former chickens displayed underdeveloped genital apparatus, no eggs being observed in their uterus. The experimental chickens were thus immunized with a single dose of the vaccine. (auth)

# Ecology

*Refer also to abstracts 14079, 14383, 14391–14396, 14398, 14399, 14481, 14483, 14509, and 16115.*

**14442** (BMI-171-22) BIOENVIRONMENTAL AND RADIOLOGICAL-SAFETY FEASIBILITY STUDIES. ATLANTIC–PACIFIC INTEROCEANIC CANAL. FINAL REPORT. FRESHWATER ECOLOGY. Templeton, W. L.; Dean, J. M.; Watson, D. G.; Rancitelli, L. A. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.); Loftin, H. G. (Florida State Univ., Tallahassee). 31 Oct 1969. Contract AT(26-1)-171. 131p. Dep. CFSTI.

For Battelle Memorial Inst., Columbus, Ohio.

Studies were conducted in the freshwater environment to acquire data needed to predict and evaluate the potential radiation hazards to human populations in the defined regions of proposed nuclear excavations in Colombia and the Republic of Panama. The data describe the elemental composition of the major components of the ecosystem and report the calculated stable-element concentration factors for the major food organism. From these base-line values, predictions can be made of the potential maximum radionuclide intake by populations using freshwater resources. The following specific topics are discussed in the report: physical characteristics of rivers; description of sampling sites; sampling procedures; analytical procedures; chemical composition of tropical rivers; composition of river sediments from Panama and Colombia; taxonomy and distribution of freshwater fishes; chemical composition of aquatic organisms; natural and weapon test-fallout-radionuclides in the freshwater ecosystem; concentration factors; the utilization of the freshwater ecosystem; and estimation of potential radiation dose. (E.R.B.)

**14443** (RLO-1750-54) ECOLOGICAL STUDIES OF RADIOACTIVITY IN THE COLUMBIA RIVER ESTUARY AND ADJACENT PACIFIC OCEAN. Progress Report, July 1, 1968–June 30, 1969. McCauley, James E. (comp. and ed.) (Oregon State Univ., Corvallis. Dept. of Oceanography). Jul 1969. Contract AT(45-1)-1750. 316p. Dep. CFSTI.

Separate abstracts were prepared for 32 of the 64 papers in this report. Thirty-one of the other papers dealt with topics of ecological interest, but were not within the scope of NSA. These topics included trace element studies, chemical analysis of channel sediments, ecological studies of marine gastropods off the Oregon coast, feeding studies in the Columbia River Estuary ecosystem, and estuary-ocean boundary studies. The other paper was not included because it was in abstract form only for future publication. Sections are also included in the report which list student participation and abstracts of resultant theses, papers presented and meetings attended by the staff, reprints of published papers, and publications relating to the topic of this report. (E.R.B.)

*For abstracts of individual papers see: 13767, 13809, 13810, 14000, 14043–14053, 14082, 14098–14100, 14171, 14383, 14391–14399, 14444, and 14445.*

**14444** (RLO-1750-54, pp 130-2) ECOLOGY AND RADIOECOLOGY OF BENTHIC ANIMALS. Carey, A. G. Jr. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Ecological and radioecological studies on benthic fauna and their environment in the northeast Pacific Ocean off Oregon were concluded. These studies were designed to determine: the species composition, distribution, and abundance of benthic invertebrates; the interactions of the fauna with its environment; and the role of the benthic invertebrate fauna in the concentration, transport, and cycling of radioecologically important elements. The project in progress at the time of this reporting was designed to determine seasonal variations in: the distribution and concentration of radionuclides in the fauna in space and time; and the cycling of elements in the bottom environment at various depths and distances from the mouth of the Columbia River. Analyses of these data to date indicate that seasonal variations exist in the levels of $^{65}Zn$ in the fauna from 50 to 2800 meters depth. Radio- and trace element analyses of sediments and bottom water from the mouth of the Columbia River are underway. (E.R.B.)

**14445** (RLO-1750-54, pp 133-40) RADIOECOLOGY OF BENTHIC FISHES. Vanderploeg, H. A. (Oregon State Univ., Corvallis. Dept. of Oceanography).

The $^{65}Zn$ radioecology of benthic fishes caught in the northeast Pacific Ocean adjacent to the mouth of the Columbia River was examined. The purpose of this study was to determine variations in the specific activity of $^{65}Zn$ of benthic fishes caught at a single depth as it relates to season, distance from mouth of the Columbia River, and species ecology. Data from a total of 83 samples representing 18 species caught at nine stations (six at 200 meters and three at 2300 to 2800 meters) indicated that no variations existed in the specific activity of the samples as a result of any of these three variables. An exception occurred in samples representing three species caught at 200 meters. These species showed station or seasonal differences, but no trend was evident from which a generalization could be made. (E.R.B.)

## Genetics and Cytogenetics

**14446** RADIATION-SENSITIVE MUTANTS OF T4D. I. T4y: A NEW RADIATION-SENSITIVE MUTANT; EFFECT OF THE MUTATION ON RADIATION SURVIVAL, GROWTH, AND RECOMBINATION. Boyle, John Michael; Symonds, N. (Univ. of Sussex, Brighton, Eng.). Mutat. Res.; 8: 431-9 (Nov-Dec 1969).

The isolation of a new radiosensitive mutant of bacteriophage $T_4$, called y is described. $T_4y$ is an amber mutant in that its behavior is only abnormal when growing on bacterial strains that do not possess an amber suppressor. During growth in such strains, y has the following properties, compared to wild-type $T_4$: twice the sensitivity to uv irradiation; 30% more sensitivity to $\gamma$ irradiation; normal photoreactivation; slightly reduced multiplicity reactivation; slower rate of intracellular phage development, and a burst size reduced by about one half; and in crosses homozygous for y the recombination frequency between two standard markers is reduced by about one half. In all these characteristics the behavior of y was experimentally compared with that of the two previously isolated radiosensitive mutants of $T_4$, v and x. The comparison suggests that y functions in a similar manner to x, and differently from v. (auth)

**14447** REPAIR OF FIL$^+$ PHENOTYPE BY STREPTOMYCIN. Skavronskaya, A. G.; Smirnov, G. B. (Inst. for Epidemiology and Microbiology, Moscow). Mutat. Res.; 8: 647-50(Nov-Dec 1969).

Strains of Escherichia coli B and B/r were uv-irradiated at 2537 Å with an intensity of 2.8 erg/mm$^2$/sec and then incubated with aeration in nutrient broth with and without streptomycin (lug/ml). All irradiations and subsequent operations were carried out under yellow light. After 2 hr of incubation, diluted suspensions were plated on nutrient agar, and variations in survival were determined. Under these conditions, streptomycin markedly increased the survival of E. coli B and slightly decreased the survival of E. coli B/r. Subsequent tests in which the dilution factor, streptomycin concentration, and plating medium and technique were varied confirmed the fact that there was no correlation between inhibition of protein synthesis by streptomycin and its recovery ability. The mechanism involved appears to be related to a nonsense-type mutation in which there is a misreading of a mutated site in the fil gene. Support for the existence of such a mechanism in the work of other investigators is presented. (E.R.B.)

**14448** UV-INDUCTION OF REVERSIONS TO PROTOTROPHY SUSCEPTIBLE TO MUTATION FREQUENCY DECLINE. Skavronskaya, A. G.; Smirnov, G. B. (Inst. for Epidemiology and Microbiology, Moscow). Mutat. Res.; 8: 651-5(Nov-Dec 1969).

The phenomenon of mutation frequency decline (MFD) has been subjected to various interpretations since its discovery in 1956, but all of the interpretations are based on the assumption that MFD is the repair of a small fraction of premutational uv-radioinduced lesions. Accordingly, the extra repair is sensitive to protein synthesis. Based on the results of experiments in which the tryptophan auxotrop Escherichia coli $WP_2$ and its uv-radiosensitive mutant E. coli $WP_2$ hcr were uv-irradiated, a new point of view is presented for interpreting the phenomenon. It is suggested that protein synthesis does not inhibit repair but gives the opportunity of formation of an additional fraction of mutation damage. The absence of the latter is exhibited as MFD. Details of the experimental design are given, and where applicable, confirmation among the works of other investigators is presented. A possible explanation of the interpretation offered involves the localization of the str-$^r$ gene near the origin of DNA replication. Other explanations and questions regarding these explanations are also entertained. (E.R.B.)

**14449** VARIATIONS IN RADIOSENSITIVITY DURING THE CELL CYCLE IN A MARSUPIAL CELL LINE. Bick, Y. A. E.; Brown, J. K. (Univ. of Tasmania, Hobart. Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Mutat. Res.; 8: 613-22(Nov-Dec 1969).

A permanent marsupial cell line, with 96% diploidy, of the male Potorous tridactylus (2n = 13) was irradiated in different stages of the cell cycle. The results for first-division postirradiation show that cells in $G_2$ had more chromatid deletions and more total damage than cells in late $G_1$ and all parts of S. The unusual length of S has enabled a more detailed examination of this stage of the cell cycle. The number of total aberrations decreased with progress through S. Contrary to other reports on animal cells, the frequency of isochromatid deletions was found to vary considerably in S and $G_2$. The number of isochromatid aberrations in early S was at least twice the number found in late S for four different series of irradiation experiments. It was shown that isochromatid deletions respond to a fractionated dose as the accepted two-hit aberrations do. These data suggest that isochromatid deletions may, in part at least, originate from two-hit events. This finding can be interpreted as lending support to Revell's contention that all chromatid aberrations result from incomplete exchanges and should be regarded as multi-hit phenomena. (auth)

**14450** RADIATION-SENSITIVE MUTANTS OF T4D. II. T4y: GENETIC CHARACTERIZATION. Boyle, John Michael (Univ. of Sussex, Brighton, Eng.). Mutat. Res.; 8: 441-9 (Nov-Dec 1969).

A complementation system for uv-radiosensitive phage mutants is described. The mutants v, x, and y belong to three distinct cistrons having the wild-type allele dominant in each case. The uv-survival curves of the phenotypes of these cistrons were distinct, with sensitivities, relative to the mutant phage sensitivities, of 1.6, 3.2, and 6.8% for v, y, and x respectively. Mapping experiments showed the three mutations to be unlinked. The uv-survival properties of the double mutants vx, vy, and xy were compared, and the results strongly support the hypothesis that x and y form a class of radiosensitive mutants that function in a manner different from v. Some possible functions of x and y are discussed. (auth)

**14451** A MUTANT OF ESCHERICHIA COLI $K_{12}$ EXHIBITING VARYING ULTRAVIOLET SENSITIVITIES DEPENDING ON THE TEMPERATURE OF INCUBATION AFTER IRRADIATION. II. CROSS-SENSITIVITY, RECOVERY IN LIQUID, AND GENETIC ANALYSIS. Morimyo, Mitsuoki; Shimazu, Yoshie; Suzuki, Kenshi (National Inst. of Radiological Sciences, Chiba, Japan). Mutat. Res.; 8: 467-79(Nov-Dec 1969).

The properties of a mutant of Escherichia coli K12, URT-43, were investigated. Genetic analysis was also carried out. Cross-sensitivity was checked for 4-nitroquinoline-I-oxide and mitomycin C. In parallel with uv irradiation, URT-43 was more sensitive to both agents than its wild-type strain. However there was an apparent large temperature effect of the action of 4-nitroquinoline-I-oxide, whereas with mitomycin C the effect was only very small. Reflecting the temperature-dependent uv-radiosensitivity of URT-43 on agar plates, the irradiated URT-43 recovered well in a liquid medium at 30° but not at 42°. The recovery required all the substances essential for its normal growth, suggesting that the recovery was accompanied by growth. Irradiated URT-43 was still restorable after photoreactivation to the maximal extent. This was true for the bacteria irradiated at dry-ice temperature in which less photoreactivable injuries would be produced than in the bacteria irradiated at room temperature. These results, as well as the observation that the extent of recovery in a liquid medium of the bacteria irradiated at low temperature was much larger than that of the same bacteria after photoillumination, suggested that the recovery was due to the repair or to a certain tolerance mechanism for injuries that were not limited to the cyclobutane pyrimidine dimers. The mechanism of this recovery was not elucidated. The mutation of URT-43 was mapped by mating and transduction experiments. The efficiency of mating with an Hfr strain was not greatly affected by low and high temperatures, suggesting that the whole mechanism of recombination was not involved in the temperature-dependent recovery in question. The mutated locus was closely linked to the malB gene by transduction experiments with P1 phage. The linkage to metA was much weaker, suggesting that the mutation was located in the uvrA gene. Two typical phenotypes of URT-43, namely those with negative host-cell reactivation and temperature-dependent uv-radiosensitivity, could not be separated in these experiments. (auth)

**14452** RADIATION-SENSITIVE AND RECOMBINATIONLESS MUTANTS OF SALMONELLA TYPHIMURIUM. Eisenstark, A.; Eisenstark, R.; van, Dillewijn, J.; Roersch, A. (Kansas State Univ., Manhattan. Medical Biological Lab., TNO Rijswijk, Netherlands). Mutat. Res.; 8: 497-504(Nov-Dec 1969).

Mutants of Salmonella typhimurium sensitive to uv light fall into several categories. In addition to quantitative uv differences, some are sensitive to x-ray and chemical mutagens, some are unable to repair damage to irradiated phage (hcr), some are recombinationless (rec) and, after lysogenization, some cannot be induced to produce mature phage. More than 60 radiation-sensitive mutants were collected and classified as to phenotypes. X-ray sensitive mutants were tested for sensitivity to nitrosoguanidine and, as yet, no case was found where the two phenotypes are separable. If the mechanism of repair of damage by the two agents is identical, the use of nitrosoguanidine would be extremely helpful for inactivation measurements and in screening procedures, especially in those laboratories where x-ray equipment is not readily available. A simplified method for scoring inducibility was developed based upon the knowledge that S. typhimurium is naturally lysogenic. The rec mutants have pleiotropic properties, but these are probably due to a single mutation, since all properties became wild-type upon reversion or recombination. Among the pleiotropic properties of rec is the exhibition of liquid-holding recovery, a characteristic not seen in most of the other radiation-sensitive mutants. Three of the radiation-sensitive mutants were found by testing appropriate auxotrophs in the collection, without any selection procedure involving exposure to radiation. (auth)

**14453** ULTRAVIOLET-INDUCED MUTATIONS IN STREPTOMYCES INDICUS. Chakrabarty, S. L. (Bose Inst., Calcutta). Mutat. Res.; 8: 513-20(Nov-Dec 1969).

The wild-type strain Streptomyces indicus Chakrabarty and four mutant strains derived from it were uv-irradiated at 253.7 nm wavelength at 100 erg/mm$^2$/sec, for 20, 40, 60, and 80 sec. The survival curve was exponential, and the rate of mutation was parallel with the increasing dosage and was followed later by a decline. The mutants differed from the wild parent in reduced growth rates, changes in the shape and size of the colony, sporulation level, antibiotic activity, and variation in the color of the mycelium. Biochemical mutants were obtained that required histidine, glycine, aspartic acid, lysine, valine, methionine, ornithine, arginine, tyrosine, cysteine, proline, leucine, alanine, threonine, riboflavin, adenine, guanine, inositol, nicotinic acid, hypoxanthine, and thymine, either singly, doubly, or alternatively. The number of histidine-requiring mutants was maximal. There was marked variation in the antibiotic activity of biochemical mutants: increase, decrease, or complete absence of such activity were seen. In some of the auxotrophs, a linking of genetic characters controlling the biosynthesis of amino acids and the production of antibiotic substances was observed. (auth)

**14454** MUTAGENESIS OF ANACYSTIS NIDULANS BY N-METHYL-N'-NITRO-N-NITROSOGUANIDINE AND UV IRRADIATION. Asato, Yukio; Folsome, Clair E. (Univ. of Hawaii, Honolulu). Mutat. Res.; 8: 531-6(Nov-Dec 1969).

Inactivation of the blue-green alga, Anacystis nidulans, with nitrosoguanidine was concentration-dependent. Nitrosoguanidine-induced mutation frequencies were: $1.8 \cdot 10^{-3}$, $2.98 \cdot 10^{-3}$, $3.7 \cdot 10^{-3}$, $1.0 \cdot 10^{-3}$, and $4.8 \cdot 10^{-4}$ for yellow and blue, minute-colony-forming, filamentous or snake, and polymixin-B-resistant mutants, respectively. Ultraviolet-radioinduced damage within the experimental conditions utilized was completely photoreactivable by visible light. When a uv-irradiated culture was incubated in the dark for 9 h, a survival curve with slope $k = -0.066$ (where $k = \ln S/S_0 \cdot t^{-1}$) was observed. A small shoulder was evident, and the extrapolation of the asymptote of the curve to the ordinate showed an inactivation number of 2. Minute-colony-forming and snake mutants were also induced by uv irradiation if photoreactivation was prevented. The inability to isolate auxotrophic mutants of Anacystis nidulans was considered to be due to intrinsic properties and therefore presents a major problem in blue-green algal genetics. (auth)

**14455** GENETIC CONTROL OF SENSITIVITY TO MUTAGENIC FACTORS IN ASPERGILLUS NIDULANS. I. OBTAINING OF MUTANTS SENSITIVE TO UV LIGHT. Kameneva, S. V.; Romanova, Yu. M. (Moscow State Univ.). Genetika; 5: No. 11, 196-8(Nov 1969). (In Russian).

Sixteen mutants sensitive to uv light (uvr) were obtained from Aspergillus nidulans strain A (Roper I. A., Department of Genetics, The University of Sheffield, England) employing nitrosoguanidine. According to uv-sensitivity, the mutants were classified into five groups: variants of the first group differ from the strain uvr$^+$ only twice while mutants 19 (5th group), 100-fold. High frequency of mutations uvr (40,000 colonies treated with NG yielded 16 mutants) makes it possible to conclude that in A. nidulans uv-sensitivity can be accounted for by a great number of loci. (auth)

**14456** UV-INDUCTION OF REVERSIONS TO PROTOTROPHY DURING GROWING OF IRRADIATED BACTERIA ON ENRICHED AND DEFICIENT MEDIA. Skavronskaya, A. G.; Smirnov, G. B. (Inst. of Epidemiology and Microbiology, Moscow). Genetika; 5: No. 11, 132-42(Nov 1969). (In Russian).

The lethal and mutagenic action of uv-radiation was studied on Escherichia coli $WP_2$ and E. coli $WP_2$ hcr under different conditions of postirradiation growth. The kinetics of uv-induction of reversions to prototrophy in Hcr$^+$ strain, growing after irradiation on MT plates, is similar to the kinetics of uv-inactivation. The kinetics of reversions to prototrophy in Hcr$^+$ strain plated on SEM-agar are quite different from those obtained on MT-agar and similar to the kinetics of uv-mutagenesis in $WP_2$ hcr on both SEM and MT plates. It is suggested that the additional fraction of mutations, appearing on SEM plates in Hcr$^+$ strain, is due to the errors of excision repair which operate on replication point. The formation of mutations established on MT plates is due only to the mistake-prone postreplication repair of gaps in the daughter DNA strand. This suggestion lends support to the opinion that MFD is a result of precise excision repair in viable irradiated cells under conditions of inhibited protein synthesis. Conditions preventing MFD (supporting protein synthesis in irradiated cells) lead to the formation of an additional fraction of mutations, caused by errors introduced into the DNA in the course of excision repair. $WP_2$ hcr$^-$ cells possess the residual MFD-activity that possibly reflects the residual HCR-activity in this mutant. MFD can be induced by pantoil lactone, added to the postirradiation plating medium (SEM). The kinetics of MFD induced by pantoil lactone and occurring in the MT medium are the same. The action of pantoil lactone is affected by acriflavine. It is reasonable to suppose that MFD induced by pantoil lactone (like its action on UV-sensitivity of lon mutants) is due to the inhibition of postirradiation protein synthesis. (auth)

**14457** DEPENDENCE OF FREQUENCY OF RADIATION-INDUCED ANEUPLOIDY ON CHROMOSOME LENGTH. I. X AND IV CHROMOSOME. Zakiev, R. K.; Glotov, N. V. (Inst. of Medical Radiology, Obninsk, USSR). Genetika; 5: No. 11, 99-105(Nov 1969). (In Russian).

Frequencies of radiation-induced non-disjunction of X and IV chromosome are compared. Two three-day old females $ci^D/ey^D$ and yellow were irradiated with $^{60}$Co $\gamma$-rays at the doses of 1, 2, 3, 4 and 5 kr and mated immediately to Berlin wild males. The broods obtained within three days were registered. The curve of non-disjunction of the IV chromosome lies systematically over that of X chromosome, and the curve of the IV chromosome loss, on the contrary, lies below that of X chromosome. Correction for relative viability does not affect the qualitative conclusions. So the frequency of radiation-induced chromosome non-disjunction at equal doses is higher for shorter chromosomes, while the contrary is true for radiation-induced chromosome loss. (auth)

**14458** PHYSIOLOGICAL AND GENETIC IMPLICATIONS OF SELECTIVE MUTATION BY LIGHT AT 320 TO 400 nm. Webb, S. J.; Tai, C. C. (Univ. of Saskatchewan, Can.). Nature (London); 224: 1123-5(13 Dec 1969).

Studies are described which suggest that irradiation of semi-dehydrated airborne cells with 320 to 400 nm light may produce specific mutations. Cultures of various strains of E. coli were aerosolized into a stainless steel drum present to a given relative humidity level and the airborne cells were irradiated with $4.5 \times 10^4$ ergs/mm$^2$ of 323 to 400 nm light. The cells were then collected from the aerosol and incubated, and mutant cells were concentrated by the penicillin method. Colony counts were made on nutrient (NA), easin-methylene blue (EMB), and MM agar plates. Individual colonies were picked off the NA plates and their suspensions were spotted onto nutrient and MM agar plates. The number of these colonies unable to grow on MM agar but able to grow on nutrient agar was determined and the growth of each mutant on nutrient agar was re-isolated into saline and diluted; the nutritional requirements of the mutants were determined. The loss of ability to utilize lactose was determined directly from the colonies developed on EMB agar. The greatest number of mutant cells was obtained when the airborne cells were irradiated at 60% relative humidity; none was observed below 40% RH. For each strain, using stationary phase 24 hr cells, only one type of mutant cell was obtained, but the type varied with the strain. When Hfr H8 hr cells in the logarithmic phase of growth were, however used, a mixture of mutants was obtained, including some lactose negative and drug resistant mutants; if these cells were first synchronized by cold shock and then aerosolized and irradiated after various periods in the log phase, one kind of mutant was, however, predominant, depending on the incubation time before treatment. It is presumed that semidehydration alters the structure of the membrane-cytochrome-DNA complex so as to allow the radiant energy absorbed by the components of the cytochrome chain to be readily transferred to the DNA, and it seems that in resting stationary phase cells the light absorbing element of the membrane cytochrome chain is in intimate-contact with a given region of the bacterial

DNA. It appears also from the results obtained with the synchronized cells in log phase growth that, as the cell progresses through its life cycle, the energy producing cytochrome system is brought successively into contact with different regions of the DNA, and it is suggested that this is a genes process. Such a model would explain the rapid rates and specificity of energy transfer in living cells. (UK)

**14459** RADIATION EFFECTS ON THE ONE LOCUS-GAMETOPHYTIC SYSTEM OF SELF-INCOMPATIBILITY IN HIGHER PLANTS. de Nettancourt, D. (EURATOM–ITAL, Wageningen, Netherlands). Theor. Appl. Genet.; 39: 187-96(1969).

A brief review is presented of the temporary and permanent effects that are usually observed after irradiation treatment of self-incompatible plants with a one locus-system of gametophytic incompatibility and attempts are made to demonstrate that the study and exploitation of such effects can lead to important advances in the fields of mutation breeding, radiobiology per se, and biochemistry. The fact that irradiation treatment has only negative effects on the self-incompatibility system (inactivation of the incompatibility reaction and/or genetic losses at the S locus) is discussed in relation to the positive changes (formation of new specificities) that are observed during inbreeding. In this connection, the suggestion is made that the self-incompatible plant may perhaps be equipped with a switch system or a mutagenic mechanism that enables it to display a new specificity when this new specificity is needed for increasing the level of genetic polymorphism in the population to which the plant belongs. (auth)

**14460** STUDIES ON THE CORRELATION AND PATH-COEFFICIENTS UNDER DIFFERENT GENERATIONS AFTER SEED IRRADIATIONS. Chang, Kwon Yawl (Chinju National Agricultural Coll., Korea). J. Nucl. Sci. (Seoul), 9: Nol 1, 133-8 (1969). (In Korean).

The studies were intended to clarify the correlations between the characters and the influences upon yield of $R_3$ and $R_4$ generations of soybean varietal populations after seed irradiations. The analysis of covariances was calculated to obtain the genotypic correlations and phenotypic correlations among the five characters; branch number per plant, stem diameter, pod number per plant and stem length, etc., and the path-coefficients (calculated by Dewey's method). The results obtained are summarized as follows: The yield of soybeans was mainly associated with the characters, such as stem diameter and stem length in the $R_3$ generation, and pod number per plant and stem length in the $R_4$ generation of soybeans. Stem diameter and stem length have positively influenced directly the yield of soybeans, but remarkable variations were shown between the generations, $R_3$ and $R_4$. Branch number alone had little influence upon yield but it had rather considerable indirect influence upon yield by increasing the stem diameter and pod number per plant. Stem diameter would be increased by increasing of the stem length and branch number per plant, and also the yield could be increased by increasing of branch number per plant and pod number per plant of soybeans. As a result, it can be concluded that stem diameter is primarily determined by branch number and in turn the yield of soybeans is secondarily determined by the stem length and pod number per plant which are positively correlated with branch number per plant and stem diameter of soybeans. (auth)

**14461** STUDIES ON THE INDUCTION OF MUTATION BY MEANS OF RADIATION AND CHEMICALS. II. GERMINATION INJURY AND CHROMOSOMAL ABERRATIONS IN BARLEY. Harn, C. Y.; Kim, Y. S.; Koh, Y. S. (Radiation Research Inst. in Agriculture, Seoul). J. Nucl. Sci. (Seoul), 9: No. 1, 59-65 (1969). (In Korean).

In order to compare the effects on germination and chromosomes, dormant seeds of Chilbo barley were treated with x ray, EMS, and MMS, and germination injury and chromosomal aberrations were examined. Germination injury was slight in x-ray treatment, but statistically significant in the treatment of EMS and MMS. Optimum dose and concentration was 30 kR in x ray, 0.065 M in EMS and 0.0035 M in MMS when the seeds were soaked for 7 hours. In x-ray treatment it was observed that although the germination injury was slight, the frequency of abnormal cells was high. In EMS and MMS the result was quite contrary to that of x-ray treatment. The double chromosome bridge appeared more frequently than the single bridge in the x-irradiated population, but opposite results were observed in the populations treated with chemicals. (auth)

**14462** ABERRATIONS IN LEUKOCYTE CHROMOSOMES OF PERSONNEL OCCUPATIONALLY EXPOSED TO LOW LEVELS OF RADIATION. Brown, J. K.; McNeill, J. R. (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Radiat. Res.; 40: 534-43(Dec 1969).

Cultures of peripheral blood leukocytes were examined from ten persons occupationally exposed to γ-rays (total dose 7.7 to 36 rem over 7 to 15 years), ten persons occupationally exposed to fast neutrons and γ-rays (total dose 4.3 to 15.9 rem over 4 to 12 years) and ten normal subjects. No evidence of increased aneuploidy was noted for the exposed groups. In the gamma group dicentrics were observed in five of six persons, each with an accumulated dose in the range 12.8 to 36 rem. The incidence of chromosome aberrations was about 1% for all groups, and precluded an evaluation of a possible relationship between aberration yield and dose kinetics. (auth)

**14463** MECHANISMS OF RADIATION MUTAGENESIS IN CELLULAR AND SUBCELLULAR SYSTEMS. Bridges, B. A. (Medical Research Council Radiobiology Unit, Harwell, Eng.). Ann. Rev. Nucl. Sci.; 19: 139-78(1969).

Biological and chemical mechanisms of mutagenesis are reviewed. Evidence that direct chemical change is not important in bacterial mutagenesis is presented. Studies on production by black light of mutants of Escherichia coli resistant to bacteriophage T5 showed that mutation rates were proportional to irradiance and were up to 40 times greater than the spontaneous rate. Mutagenic effects of ultraviolet light on viruses, bacteria, and eukaryotic cells are reviewed. It is pointed out that pyrimidine dimers are important in the induction of phage mutants as they are in many other uv-induced effects and that the premutational lesion may initiate mutational changes at base pairs other than those at which the dimer is situated. For studies on effects of ultraviolet on bacteria, three types of mutation systems are in general use: mutation to bacteriophage resistance, to antibiotic resistance, and to independence from some nutritional requirement. The role of pyrimidine dimers in bacterial mutations is discussed and evidence that premutational lesions induced by ultraviolet can be required is presented. A review of studies on mutations in eukaryotic cells includes research on Asperigillus, Neurospora, Chlamydomonas, Saccharomyces, Ophiostoma, and Ustilago. Mutagenic effects of ionizing radiation on viruses, bacteria, and eukaryotic cells are reviewed. Analysis of data obtained with radiations of differing LET indicated that potentially lethal damage in Escherichia coli could be divided into two classes: double-stranded DNA damage which is largely irreparable, and single-stranded DNA damage which could be repaired to varying degrees in different strains. The significance of recombination as mutagenic process is discussed. It is concluded that expressible mutations do not arise to a significant extent as a direct action of radiation upon genetic material; it appears that initial damage is located in the DNA and that it is relatively nonspecific in that many different molecular changes may arise from one particular type of damage. (H.L.W.)

**14464** MUTATION PROCESS AND SURVIVAL RATE OF MICROCOCCUS SP. 25 AT INDUCTION WITH UV RAYS. Apine, A. Ya.; Linde, E. A. (Inst. of Microbiology, Riga). Latv. PSR Zinat. Akad. Vestis; No. 10, 116-19(1969). (In Russian)

A study was made of the action of uv radiation upon Micrococcus sp. 25. Data on survival rate of cells under the influence of various uv doses were obtained and auxotrophic variants were selected. The highest number of auxotrophic mutants was obtained at 28950 erg/sq. mm of uv radiation (15.4 percent), when cell survival rate was 0.06 percent. Higher doses of uv lowered the yield of auxotrophic mutants. (auth)

**14465** DISTRIBUTION OF CHROMOSOME EXCHANGES INDUCED BY RADIATION OF DIFFERENT QUALITIES. Bhatt, B. Y.; Bora, K. C.; Singh, B. B. (Bhabha Atomic Research Centre, Bombay). pp 27-38 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

It has been shown that the distribution of chromosome exchanges induced by ionizing radiation in wheat seeds, Vicia faba roots, and Tradescantia microspores does not follow a clear-cut pattern. It is sometimes random and sometimes binomial. Although the total number of radiation-induced exchanges in seeds was found to depend on the intensity of fast neutrons, high intensity being less effective than low intensity, the pattern of their distribution was unaltered and remained random. Various factors affecting the distribution of chromosome exchanges induced under different conditions of irradiation are discussed and another distribution function formed by mixing the Poisson's and binomial formulas was shown to be promising and applicable in all cases. (auth)

**14466** CHROMOSOME ABERRATIONS AND EFFECTIVE LET OF HARD X-RAYS. Neary, G. J. (Medical Research Council, Harwell, Eng.). pp 135-48 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

Because of the very heterogeneous physical quality characteristics of hard x or gamma radiation, any useful evaluation of quality in relation to a particular biological effect requires a knowledge of the basic mechanisms of the process. Data on chromosome aberration formation obtained in conditions of well-defined LET, using track-segments of heavy particles and monochromatic soft x rays, have provided the basic information on this process and led to a biophysical model. Aberration production by a low-energy electron depends not only on the LET but also on the track-length in relation to a characteristic length which is interpreted as the radius of a region within which two damaged chromosomes can interact to give an aberration. On the basis of this model, the effectiveness of hard x rays can be accounted for by reference to their LET distributions. The effective LET for aberration production depends on the characteristic site-radius for the particular type of aberration in the cells considered. (auth)

**14467** PROPERTIES OF A TEMPERATURE-SENSITIVE, RADIATION-SENSITIVE MUTANT OF ESCHERICHIA COLI. II. DNA REPLICATION. Pauling, Crellin; Hamm, Lyla (Univ. of California, Riverside). Proc. Nat. Acad. Sci. U. S.; 64: 1195-1202(Dec 1969).

A temperature-sensitive, uv-radiosensitive mutant of Escherichia coli is described. In vitro assays demonstrated that DNA ligase activity was markedly reduced in this strain relative to that of the parent strain. Okazaki fragments of newly replicated DNA accumulated in this mutant strain upon growth at the restrictive temperature. These results imply that the same enzyme, DNA ligase, functions both in normal semiconservative replication and in nonconservative repair replication of DNA. (auth)

**14468** ORIGIN OF TERTIARY MONOSOMICS IN THE TOMATO. Ramanna, M. S. (Agricultural Univ., Wageningen, Netherlands). Genetica; 40: 279-88(1969).

Six aneuploid tomato plants with $2n - 1 = 23$ chromosomes were observed in populations grown from the seedlings treated with thermal neutrons and from seeds treated with x rays. Four of the aneuploids were tertiary monosomics in which, as a result of centrometric interchanges between two different chromosomes, two whole arms were missing from the complement and two arms connected at the centromere. In one aneuploid, as a result of centromeric breakage, the two short arms of a homologous pair were missing from the complement and the two long arms connected to the long arm and the short arm respectively of another chromosome in which breakage had occurred also at the centromere. In one aneuploid, the interchange has occurred in the arms, and not in the centromere. Here the aneuploid condition is due to the loss of an arm with a centromere and a short piece of the other arm. In most of the tertiary monosomics the missing arms were either the short arms of submetacentric chromosomes or any of the arms of metacentric chromosomes. However, in one case the long arms of two submetacentric chromosomes were lost from the complement. That in spite of such large chromosomal deletions the sporophyte can survive, may be due to the fact that the aberrant plants are mostly chimeras. (auth)

**14469** IRRADIATION-INDUCED ANEUPLOIDY AND ARCHITECTURAL ALTERATIONS OF CHROMOSOMES IN CORIANDRUM SATIVUM L. Raghuvanshi, S. S.; Chauhan, A. K. S. (Lucknow Univ., India). Curr. Sci. (India); 39: 42-3(20 Jan 1970).

Following irradiation of seeds, one plant was found to be a monosomic with a chromosome number of 21, the number being 22 in normal plants. The monosomic was weak, smaller in height, and had less spread branches than normal plants. In addition to loss of one chromosome, the radiation caused reciprocal translocations in the chromosomes of the monosomic. (H.L.W.)

**14470** THE DETECTION OF REVERSE MUTATIONS AT THE mtr LOCUS IN NEUROSPORA AND EVIDENCE FOR POSSIBLE INTRAGENIC (SECOND SITE) SUPPRESSOR MUTATIONS. Brink, Neil G.; Kariya, Beverly; Stadler, David R. (Univ. of Washington, Seattle). Genetics; 63: 281-90(Oct 1969).

Induced mutations were analyzed in a strain of Neurospora crassa that carried a mutant gene (hist) resulting in a requirement for histidine and another (mtr) which destroyed the activity of a normal uptake system for amino acids. Cells were treated with mutagens and then plated in a medium which selected reversions at both loci. The selected revertants also included mutations at a third locus, a suppressor of mtr. The chemical mutagens showed three distinct patterns with regard to the relative frequencies of induced mutations at these three loci. The pattern shown by the alkylating agents DES and EMS was different from that shown by NMG, and both of these patterns differed from that of ICR-170. A genetic analysis of revertants at the mtr locus showed that they had resulted from events at sites which were separable from the original mutant site. It appears that this was a frame-shift mutant whose reversion was efficiently induced by ICR-170 and by uv, less efficiently by DES and EMS, and not at all by NMG. (auth)

**14471** GENETIC EFFECTS OF SPERMATOGONIAL IRRADIATION ON GROWTH AND AGE AT SEXUAL MATURITY IN RATS. Taylor, B. A.; Chapman, A. B. (Univ. of Wisconsin, Madison). Contract AT(11-1)-697. Genetics; 63: 441-54(Oct 1969).

Significant effects of cumulative spermatogonial irradiation were observed in a population of rats, the males of which were exposed to a fractionated dose of 450 R x radiation administered at 10, 12, and 14 weeks of age. Observations were made on eight generations. Observations were made on age of vaginal opening and body weights (adjusted for litter size, parity, and age of dam). Analyses of the means, the within-litter variances, and the covariances between offspring and parent, indicated that the average heterozygous effects of induced mutations are to increase body weights and decrease age at vaginal opening, while the average homozygous effects are to decrease body weights and to increase age at vaginal opening. Overdominance of induced mutations with respect to these quantitative traits is, therefore, indicated. (C.H.)

**14472** SOME COMPONENTS OF X RAY-INDUCED CROSSING OVER IN FEMALES OF DROSOPHILA MELANOGASTER. Roberts, Paul A. (Oak Ridge National Lab., Tenn.). Genetics; 63: 387-404(Oct 1969).

Evidence is presented that crossing over between homologous chromosomes of Drosophila melanogaster is modified in two ways by x rays, depending on the position and structure of the chromosomal region. In heterochromatic regions exchanges occur by breakage and rejoining in both early and late oocytes and in oogonia. There is a high frequency of exchange between the short and long arms of the X (anisobrachial exchanges). In euchromatin a low level of x ray-induced exchanges occurs in all cell stages, but the conspicuous increase in proximal and decrease in distal crossovers in the normal X apparently result from radiation effects on oogonial chromosomes that persist through one or more cell divisions until manifested at the time of crossing over in early oocytes. A possible explanation for crossover decreases in terms of enzyme-mediated steps common to the processes of crossing over and chromosome repair is considered. (auth)

**14473** MUTATIONAL ANALYSIS OF CONIDIAL DEVELOPMENT IN ASPERGILLUS NIDULANS. Clutterbuck, A. J. (Univ. of Glasgow). Genetics; 63: 317-27(Oct 1969).

A study of the spectrum of mutants induced by DES, NMG, nitrous acid, or uv radiation, affecting the development of the conidial apparatus of Aspergillus nidulans suggests that there are very few loci specifically concerned with this development. Mutants affecting only the stages of development after the initiation of the conidiophore have been studied, thus excluding mutants simultaneously defective in hyphal growth and sporulation. Within these limits mutants of six phenotypes have been found. In two of these only the structure of the conidium itself is affected. Two others conidiate, but in an abnormal manner, and are also defective in sexual reproduction. Despite the fact that search was concentrated on aconidial mutants, only two loci which give such mutants have been found. These are designated abacus and bristle loci: 40 allelic mutants of the former type have been studied, and 37 of the latter. The behavior of bristle mutants shows that this locus affects both vesicle and sterigma development and it is suggested that its function may be related to the phenomenon of hyphal/yeast dimorphism. Some mutants involving conidiophore pigmentation are also described. (auth)

**14474** INTRAGENCI RECOMBINATION AT THE mtr LOCUS OF NEUROSPORA WITH SEGREGATION AT AN UNSELECTED SITE. Stadler, David R.; Kariya, Beverly (Univ. of Washington, Seattle). Genetics; 63: 291-316(Oct 1969).

A two-way selection system, using uv treated conidia, permitted the recovery of both mutant and nonmutant products of recombination at the mtr locus of Neurospora crassa. A conditional mutant at this locus has been used to provide an unselected site of segregation among progeny selected for recombination within the same gene. These five-point crosses (two outside markers plus three sites within mtr) have led to several conclusions about the role of gene conversion (nonreciprocal segregation) in intragenic recombination: conversion involves a continuous segment of genetic material; a recombination event frequently involves the conversion of two separate segments within the same gene; recombination between mutant sites in the mtr gene only occurs in a small fraction of those meioses which involve gene conversion at this locus. Extensive analyses of mutant and nonmutant products of recombination at the mtr locus have revealed no evidence of new genetic sequences (different from those provided by the two parents). It

appears that meiotic recombination at this locus is not a mutagenic event. (auth)

**14475** THE FREQUENCY OF X RAY-INDUCED DOMINANT AND RECESSIVE LETHAL MUTATIONS IN THE RAT. Taylor, B. A.; Chapman, A. B. (Univ. of Wisconsin, Madison). Contract AT(11-1)-697. Genetics; 63: 455-66(Oct 1969).

Litter size data were used to estimate the x radioinduced mutation rates to dominant and recessive lethals following spermatogonial irradiation over 14 generations in the rat. The estimates obtained are in good agreement with comparable estimates in mice. The data indicate that most lethals kill in the prenatal period. There was no evidence for the occurrence of mutations with mildly detrimental heterozygous effects. (auth)

# Health Physics and Safety

*Refer also to abstracts 13726, 13874, 14130, and 16219.*

**14476** (STI/PUB-171) BIOPHYSICAL ASPECTS OF RADIATION QUALITY. Second Panel Report. Panel Proceedings Series. Report of a Panel Held in Vienna, 10-14 April 1967. (International Atomic Energy Agency, Vienna (Austria)). Mar 1968. 186p. (In several languages). (CONF-670423). IAEA $3.00.

Twelve separate abstracts were prepared for inclusion in NSA. In addition, the report contains one paper previously published in NSA and one abstract of a paper. The discussions following the presentation of papers and the conclusions and recommendations are provided. (C.O.)

*For abstracts of individual papers see: 13980, 14465, 14466, 14498-14502, 14572, 14573, 14601, and 14602.*

## Radioactive Contamination and Decontamination

*Refer also to abstracts 14390 and 14401.*

**14477** (AD-688940) BIOLOGICAL AND RADIOLOGICAL EFFECTS OF FALLOUT FROM NUCLEAR EXPLOSIONS. CHAPTER 3. DISTRIBUTION OF LOCAL FALLOUT. Final Report, 1962-1964. Miller, Carl F. (URS Research Co., Burlingame, Calif.). May 1969. Contract N00228-68-C-2390. 106p. (URS-702-1; USNRDL-TRC-68-61). CFSTI.

The report summarizes the fallout pattern scaling relationships that were developed in the period 1962 to 1964; the report includes the values of the scaling equation coefficients that were derived from selected fallout pattern data. The meaning of the scalar wind speed multiplier that is used in the scaling equations is discussed relative to computer applications of the scaling system and approximate wind speed adjustment factors for use with wind speed averages that may be assumed in such applications are provided. Basic equations for relating surface density of radionuclides and air ionization rates are given. Scaling equations and data are also presented for use in estimating, for any location in the fallout region, the time of fallout arrival, the time of fallout cessation, the variation of the exposure rate (i.e., air ionization rate in roentgens per hour) with time during fallout arrival, and the total potential exposure from the time of fallout arrival to selected later times. (auth) (CFSTI)

**14478** (KFK-1019) INVESTIGATION OF THE DECONTAMINATION ACTION OF COMMERCIAL AND LABORATORY DETERGENTS. Schmitz, J. (Kernforschungszentrum, Karlsruhe (West Germany). Laboratorium fuer Isotopentechnik). July 1969. 23p. (In German). Dep. CFSTI (U. S. Sales Only).

A comparative test was made of the decontamination efficiency of commercial detergents and of caustic soda solutions, hydrochloric acid, chromosulfuric acid, and water. Duran 50 ground glass joints NS 14.5 were contaminated to saturation with $^{131}I$, $^{133}Ba$, and $^{137}Cs$. The contaminated ground glass sections were suspended in the solution to be investigated and after an established time interval the residual activity on the ground glass section was measured. The plotting of the residual activity against the reaction time of the detergent yielded the decontamination curve, from which the decontamination efficiency of the detergent could be read directly. The studies were conducted at 20, 50, and 70°C using two different decontamination methods: the static immersion of the contaminated section in the solutions and the dynamic motion of the solution around the section by a shaking machine with defined frequency. The static reaction led, at high temperature and long reaction times, to a satisfactory decontamination rate in which $^{133}Ba$ was the most difficult to remove. The dynamic reaction of some of the rinsing agents resulted in decontamination rates of 99.9% within a short period of time, permitting further use of the contaminated glass apparatus. The decontamination efficiency of the individual detergents is described and an explanation of the decontamination processes on ground glass surfaces is discussed. (tr-auth)

**14479** (UCRL-19354) REPORT OF THE BIOASSAY PROGRAM, JULY 1968-JUNE 1969. Low-Beer, Anne de G.; Sargent, Thornton W.; Wright, Stephen R.; Buckley, Barbara C. (California Univ., Berkeley. Lawrence Radiation Lab.). Aug 1969. Contract W-7405-eng-48. 10p. Dep. CFSTI.

This report of the Bioassay Program updates the information contained in UCRL-18588 with respect to results of radiochemical analysis of biological samples and whole-body counts on selected employees of LRL, and to continuing studies of in vivo counting of alpha activity by means of a solid-state semiconductor. It presents new developments, including continuing research with the Si(Li) wound counter, and acquisition and operation of a system for alpha pulse-height analysis, and it describes a survey of alpha contamination in Bay Area residents who have no occupational exposure to radiation. (auth)

**14480** EFFECT OF ALGINATE ON THE ABSORPTION AND EXCRETION OF $^{203}Pb$ IN RATS FED MILK AND NORMAL DIETS. Carr, T. E. F.; Nolan, J.; Durakovic, A. (Medical Research Council, Harwell, Eng.). Nature (London); 224: 1115(13 Dec 1969).

In the experiments described the rats were fed a high milk diet, as well as their normal high cereal content diet, so as to resemble more closely human diet and particularly that of infants. Sodium alginate (10%) was added to the daily diet, together with 10 $\mu$Ci carrier-free $^{203}Pb$ in 0.001M nitric acid. Urine and feces and subsequently the carcass, were analyzed. It was found that 10% alginate in the standard laboratory diet increased $^{203}Pb$ absorption by a factor of about 2.5, but with a milk diet an approximately equal reduction was observed. The preliminary results indicate that the effect of alginate on lead absorption is small, but depends on dietary conditions, and that the adoption of alginate therapy to reduce $^{90}Sr$ absorption in contaminated environments could not be complicated by any major increase in lead absorption. In the young, who are most at risk, some slight protection might be expected to result. (UK)

**14481** ON THE QUESTION OF THE CHARGEABILITY OF THE RHINE WITH RADIOACTIVE NUCLIDES. IV. SORPTION OF RADIONUCLIDES BY THE PLANKTON FRACTION OF SUSPENDED SUBSTANCES IN THE RHINE. Schneider, Horst (Isotopenlaboratorium, Koblenz, Ger.). Gas- Wasserfach., 110: 647-52(June 13, 1969). (In German).

The sorption capacity of natural plankton from three positions on the Rhine (Oehningen, Koblenz, and Wesel) for different radionuclides was studied. The concentration factors for these nuclides ranged as follows: $^{85}Sr$, 13-32; $^{65}Zn$, 500-1400; $^{137}Cs$, 850-1600; $^{32}P$, 2000-3600; $^{131}I$, 1500-4500. Comparison with the sorption capacity of green algae Ankistrodesmus falcatus (Corda) and with Rhine sediments is made; the plankton show considerably increased sorbability for $^{131}I$ over both the other constituents. The results allow an estimation to be made of the sorption capacity of suspended material in rivers for radioactive nuclides. (BBB)

**14482** RADIOACTIVITY IN DRINKING WATER IN THE UNITED KINGDOM: 1967 RESULTS. British Water Supply (U.K.); 1: 42-5(Feb 1969).

A report giving the amounts of $^{90}Sr$ and $^{137}Cs$ found in 1967 in seven selected drinking water supplies in the United Kingdom is reviewed. The determinations were carried out as part of the Government's program for monitoring radioactive fallout. The four impounded water supplies sampled throughout 1967 comprised one each from England, Wales, Scotland, and Northern Ireland. The River Thames supplies used at Oxford and London were examined, as also was underground water used at Brighton. Only very small amounts of $^{90}Sr$ and no $^{137}Cs$ were found in an underground supply at Brighton. The average concentration of $^{90}Sr$ in the Oxford river-derived supply in 1967 was 0.26 p Ci/l, i.e., 21% less than in 1966. The value for the London supply from the Thames was 0.55 pCi/l, 13% lower than in 1966. Levels of $^{137}Cs$ in the river-derived supplies were again much lower than those for $^{90}Sr$. Average concentrations of $^{90}Sr$ in 1967 for the tested impounded waters of Belfast, Glasgow, Manchester, and Lleyn (now Eryri) were 1.32, 1.97, 1.59, and 3.33 pCi/l, respectively. The corresponding values for 1966 were 1.81, 2.04, 2.16, and 2.92 pCi/l. Each of the impounded waters contained less $^{90}Sr$ than in 1966. The average annual values ranged from 0.24 pCi/l for Manchester to 1.12 pCi/l for Belfast. Although it is not possible to give a value for the average intake of either isotope in drinking water, it has remained small compared with the total intake in the diet. (BBB)

## Dosimetry and Monitoring

*Refer also to abstracts 14192, 14312, 14549, 14559, 14560, 14563, 14618, and 15703.*

**14483** (SWRHL-94-r) OFF-SITE RADIOLOGICAL SAFETY AND RESIDENT EVACUATION PROGRAM FOR PROJECT RULISON. Detonation Phase. (Public Health Service, Las Vegas, Nev. Southwestern Radiological Health Lab.). Jan 1970. 69p. (PNE-R-14). Dep. CFSTI.

Project Rulison is the second jointly-sponsored government-industry nuclear experiment performed to determine the feasibility of using nuclear explosives to stimulate production and recovery of natural gas from low permeability gas-bearing formations. The operational procedures and results of the off-site radiological safety and resident evacuation programs conducted for the detonation phase of the experiment by the Public Health Service (PHS), Southwestern Radiological Health Laboratory (SWRHL) are presented. The off-site radiological safety program included operating a system of environmental surveillance networks before and after the detonation, and fielding radiation monitoring teams for the detonation. All surveillance and monitoring results indicated no changes in environmental radioactivity levels following the experiment. Based on predicted ground motion in the vicinity of the test well as a result of the nuclear explosion, residents within five miles of the test well were evacuated from the area for several hours on D-day during the detonation period, and gas and electrical utilities in the area were disconnected to minimize fire hazards. PHS representatives remained in the area with five families who chose to remain at home. Arrangements were made for all residents in the area between five and nine miles from the test well to be outdoors and away from structures at detonation time to minimize any possible hazard from falling objects or structural damage. All evacuation procedures went smoothly, and no accidents or injuries to residents were reported before or after the detonation. (auth)

**14484** COMPARISON OF A RADIOGRAPHIC MEASUREMENT OF X-RAY BEAM QUALITY WITH SPECTRAL MEASUREMENTS. Ardran, G. M.; Burt, A. K.; Crooks, H. E.; Peaple, L. H. J. (Atomic Energy Research Establishment, Harwell, Eng.). Brit. J. Radiol.; 42: 757-61(Oct 1969).

For the routine assessment and control of diagnostic x-ray beam quality a simple and reliable instrument is required. Such a device, consisting of a copper penetrameter employing an improved step wedge technique and calibrated against a constant potential generator, has been described by Ardran and Crooks (1968). In practice two radiographs are taken, the first with the beam filtered at source by 1.5 mm of copper, the second with the unfiltered beam. The first exposure compares the quality of the high energy end of the spectrum with that of the standard beam produced by the constant potential generator and the tube voltage is adjusted so that the effective voltage is the same. The unfiltered beams are then compared using the same effective voltage and the lower energy portion of the spectrum matched by the addition of a suitable aluminium absorber to produce the same "effective inherent" or total filtration (e.g., the standard 2 mm Al equivalent.) In the paper the results obtained with a copper penetrameter were compared with measurements made with a scintillation spectrometer for a variety of x-ray generators and operating conditions. The penetrameter results, expressed as a copper reference number (CRN), are related by power functions, to the mean photon energy obtained from the spectra. For a given tube potential waveform an exponential relationship between the peak potential, estimated from the spectra, and the CRN is demonstrated. (auth) (UK)

**14485** BREMSSTRAHLUNG (4,3 MeV) IN COMBINED THERAPY OF UTERINE CERVIX CANCER. Belomoeva, R. V.; Gabelov, A. A.; Palladieva, N. M. Med. Radiol.; 12: No. 12, 8-13(Dec 1969). (In Russian).

Numerical data for determining doses in the pelvis with different methods of intracavitary introduction of the $^{60}Co$ preparations are given. In accordance with the dose distribution in intracavitary therapy, special shaping filters are employed through which external bremsstrahlung is directed. (auth)

**14486** DOSE CALCULATIONS IN TELECOBALT THERAPY BY COMPUTER. Leetz, H.-K. (Univ. Saarlandes, Homburg, Ger.). Roentgenpraxis; 22: 257-65(Nov 1969). (In German).

Theoretical considerations of dose calculations for cobalt-60 teletherapy are discussed and the mathematical equations are presented and explained. Based on the mathematical concepts, programs for a Phillips P 9202 computer are worked out and described in detail. Several flow diagrams demonstrate the computer procedure. Time requirements for dose calculations are briefly discussed. (H.B.G.)

**14487** THE DETERMINATION OF LET SPECTRA FROM ENERGY-PROPORTIONAL PULSE-HEIGHT MEASUREMENTS. I. TRACK-LENGTH DISTRIBUTIONS IN CAVITIES. Birkhoff, R. D.; Turner, J. E.; Anderson, V. E.; Feola, J. M.; Hamm, R. N. (Oak Ridge National Lab., Tenn.). Health Phys.; 18: 1-14(Jan 1970).

Observed pulse-height spectra from energy-proportional devices depend, in part, on the distribution of charged-particle track lengths in the sensitive volume of the device. A short bibliography on track-length distributions in cavities of various shapes is given and the results of available calculations are summarized. Analytic solutions or partial solutions exist for the distributions of chord lengths from isotropic tracks incident on a sphere, infinite slab and finite and infinite circular cylinders. The present paper utilizes a Monte Carlo technique to calculate chord-length distributions in right circular cylinders of finite length. The results obtained by this method agree with one set of published curves which, in turn, are in disagreement at short chord lengths with another set. The Monte Carlo method employed here can be used to calculate track-length distributions in cavities of arbitrary shapes bombarded by particles having any specified spatial distribution of track directions. The particle tracks need not span the cavity. The distributions are used in an accompanying paper, Part II, in the unfolding of LET spectra from pulse-height measurements. (auth) (UK)

**14488** THE DETERMINATION OF LET SPECTRA FROM ENERGY-PROPORTIONAL PULSE-HEIGHT MEASUREMENTS. II. A MONTE CARLO UNFOLDING PROCEDURE. Turner, J. E.; Anderson, V. E.; Birkhoff, R. D.; Johnson, D. R. (Oak Ridge National Lab., Tenn.). Health Phys.; 18: 15-24(Jan 1970).

The mathematical problem of unfolding LET spectra from observed pulse-height measurement is formulated and analytic solutions for the sphere and infinite slab are discussed. An iterative Monte Carlo procedure is presented for unfolding LET spectra from pulse-height measurements from any energy-proportional device. The method, which utilizes track-length distributions obtained by the technique described in the preceding paper, Part I, places no restrictions on the geometrical shape of the device or on the geometry of the source of particles bombarding it. The procedure is applied to examples of charged-particle and neutron irradiation in which both spherical and cylindrical proportional counters are considered. While no exhaustive study is attempted, the results show that, even in its simplest form, the method could be adapted to routine health physics monitoring. Ways of improving the procedure and incorporating more elaborate programs are discussed. (auth) (UK)

**14489** RADIATION DOSES IN X-RAY EXAMINATIONS OF PATIENTS WITH CONGENITAL FEMORAL DISLOCATION. Koroleva, T. M.; Zakharenko, Yu. S. (Inst. of Radiation Protection, Leningrad). Med. Radiol.; 12: No. 12, 37-42(Dec 1969). (In Russian).

Average gonad doses received during x-ray examinations from the time of birth till the age of 20 were determined in 350 female patients with congenital femoral dislocation. The mean gonad dose accumulated as the result of all examinations by the age of 20 was $5.6 \pm 0.2$ Rad. (auth)

**14490** DETERMINATION OF ABSORBED DOSES IN DIAGNOSTIC USE OF LABELED COMPOUNDS BY MEASURING TOTAL RADIOACTIVITY. Sereda, M. G. (Inst. of Medical Radiology, Moscow). Med. Radiol.; 12: No. 12, 65-9(Dec 1969). (In Russian).

Estimation of absorbed doses from $\gamma$-emitting radioisotopes is a difficult task requiring intricate modeling. The use of a counter for measuring total radioactivity in man helps to directly determine absorbed doses coming from $\gamma$ sources with any spectrum and spatial distribution incorporated in man. The absorbed energy can be measured by considering the difference in the spectra of man and sources without the absorber. A program for determination of absorbed doses from $^{131}I$ and $^{59}Fe$ was compiled for the Minsk-22 unit. The dose values obtained and measured with the total radioactivity counter were smaller than the estimated doses by less than 15%. (auth)

**14491** LINEAR PROGRAMMING IN SELECTING OPTIMAL CONDITIONS FOR RADIATION THERAPY. Klepper, L. Ya. (Central Inst. of Economics and Mathematics, Moscow). Med. Radiol.; 12: No. 12, 69-76(Dec 1969). (In Russian).

Mathematical interpretation of the problem involving the choice of optimal plans for irradiation leads to a system of linear limitations with a special function whose form is unknown. A method for constructing a special linear function with the aid of relative multipliers or evaluations is proposed and its effectiveness is substantiated experimentally. (auth)

**14492** RADIONUCLIDE DECAY SCHEMES AND NUCLEAR PARAMETERS FOR USE IN RADIATION-DOSE ESTIMATION. Dillman, L. T. (Oak Ridge National Lab., Tenn. Ohio Wesleyan Univ., Delaware, Ohio). J. Nucl. Med.; 10: Suppl. No. 2, 7-32 (Mar 1969).

A computer program was developed for use in calculating the intensities and respective energies of the radiations emitted by 24 radioisotopes of interest in nuclear medicine for each of the following processes: alpha emission, electron or positron emission, electron capture, and internal conversion of gamma rays. The ultimate goal is a computer code that uses nuclear decay data as input information and calculates the energy absorbed per decay for the particular organ or organs of interest for use in radiation dose estimations. Data are included for $^{14}C$, $^{137}Cs$, $^{51}Cr$, $^{57}Co$, $^{58}Co$, $^{18}F$, $^{198}Au$, $^{113m}In$, $^{123}I$, $^{125}I$, $^{131}I$, $^{59}Fe$, $^{197}Hg$, $^{203}Hg$, $^{103}Pd$, $^{32}P$, $^{42}K$, $^{75}Se$, $^{24}Na$, $^{85}Sr$, $^{89m}Sr$, $^{90}Sr$, $^{99m}Tc$, and tritium, and all radioactive daughters of these radionuclides. The validity of the computer results was tested against previously determined results and good agreement was found for a wide variety of cases. (C.H.)

**14493** GONADAL EXPOSURE FROM INTRAORAL X-RAY EXAMINATION. Niwa, Katsumi (Tokyo Dental Coll.). Shika Gakuho, 69: 216-34(Mar. 1969). (In Japanese).

Gonadal exposure of patients during intraoral x-ray examination was measured with a Mix-D phantom. The effective energy of the x rays employed, generated by a dental x-ray machine operated at 64 kVp with total filtration of 1.5 mm Al, was 27 keV. The effective energies of the secondary x rays penetrating different depths (3.5 cm, 7.5 cm, and 12.5 cm) of Mix-D, soft tissue, and water exposed to x rays of 27 keV were 30 to 35 keV. Values of relative doses of secondary x rays scattered from material exposed to an x ray of 27 keV revealed that elements of atomic number lower than 20 (water, Mix-D, soft tissue, aluminium, and paraffin) scattered the most intensive secondary x rays. Lead emits moderately intensive ones, but the other elements involved irradiated secondary x rays of less intensity. Thus, secondary x rays scattered from the soft tissue of a patient under dental x-ray examination make a greater contribution to the gonadal doses than the contribution of secondary x rays scattered from the dental chair, wall, or floor. During radiography of maxillary teeth, doses of radiation leaking from the head of the x-ray machine and reaching the gonad region were too small to make an appreciable contribution to gonadal exposure. Furthermore, their values did not vary with the region examined or the x-ray directions. During radiography of maxillary teeth, the amount of radiation reaching the gonadal area varied with the x-ray direction and reached maximum value when the beam was directed toward the gonads. This indicates that the primary x-ray itself makes a fairly large contribution to gonadal exposure. A head mounted with a long cone tended to increase gonadal exposure from leakage x rays. During radiography of mandibular teeth, the amount of radiation that reached the gonadal area varied with the x-ray direction, and particularly with the positioning of the head of the machine. Leakage radiation, therefore, makes a moderate contribution to gonadal exposure. During radiography of maxillary teeth, a long cone reduces the amount of secondary radiation reaching the gonadal area, but in radiography of mandibular teeth, the long cone causes greater gonadal exposure because of increasing gonadal radiation doses from leakage. Actual gonadal doses of male patients examined in a 10-film series made at 64 kVp were 0.13 to 0.25 mR with a long cone and 0.06 to 0.07 mR with a short cone. A leaded rubber apron reduced the doses by $1/10$ to $1/20$ with a long cone and by $1/6$ with a short cone. Draping a leaded rubber apron over the chest and pelvic region of the patient is useful in reducing the radiation reaching the patient in dental radiography. (BBB)

**14494** ESTIMATION OF ABSORBED DOSES IN THE CELL NUCLEUS AFTER INCORPORATION OF $^{3}H$- OR $^{14}C$-LABELED THYMIDINE. Taegder, K.; Scheuermann, W. (Technische Univ., Hanover. Gesellschaft fuer Strahlenforschung mbH., Munich). Radiat. Res.; 41: 202-16(Jan 1970).

The estimation of absorbed doses in cellular and subcellular structure after incorporation of radionuclides is especially difficult if these radionuclides are distributed inhomogeneously. Such inhomogeneous distributions can be the result of an incorporation into specific parts of the structure (for example, incorporation of labeled thymidine into DNA). This directed incorporation of thymidine during and after the pulse labeling was traced by liquid scintillation counting. Besides the activity change of labeled cell nuclei, that of the cytoplasm was studied also. The data obtained allow a good estimation of the absorbed dose in the nucleus after pulse labeling with tritium- and carbon-14-labeled thymidine as well. For the calculation of the dose, procedures known from the literature are available. These procedures are compared. (auth)

**14495** THE USE OF LITHIUM FLUORIDE THERMOLUMINESCENCE DOSIMETRY IN GYNECOLOGIC RADIUM TREATMENTS. Reichel, Gerhard; Weise, W.; Morczek, A.; Bernoth, E. (Strahlentherapeutische Klinik, Magdeburg, Ger.). Zentralbl. Gynaekol.; 90: 415-22(23 Mar 1968). (In German).

Phosphorescent LiF thermoluminescence dosimetry was studied with $^{226}Ra$ implants used for gynecologic radiotherapy. The various forms of dosimeters and the measurement equipment used are described and illustrated. The linear relation between recorded dose and radiation doses of up to 10,000 R and the relative sensitivity of the dosimeters over a photon range from 0.01 to 1 MeV are demonstrated. Irradiation isodose distribution for $^{226}Ra$ implanted in the rectum was measured in patients, and measurement results with thin or thick polyvinylchloride rectal tubes filled with LiF are compared. The advantages and disadvantages of LiF thermoluminescence dosimetry are compared. The main advantages are the good tissue equivalence of LiF and the possibility of enclosing the LiF in water-tight dosimeter forms. Other advantages are independence from electrical charge, mechanical stability, low irradiation energy dependence, and the possibility of simultaneous measurement at several locations. However, a disadvantage is that, compared to ionization chambers or CdS probes that can be read immediately, results of measurements with LiF dosimeters require delay before the readings can be obtained. (BBB)

**14496** OUR NEW PARTNER, THE COMPUTER. Waggener, Ronald E.; Spicka, James Nebr. State Med. J.; 54: 203-4(Apr 1969).

The calculations necessary to establish $^{60}Co$ teletherapy tumor doses were programmed for computer analysis. One major problem was the influence of varying body contours on the dose pattern. From cross-section diagrams of patients with various tumors, standard geometric configurations were established that most closely approximated the outline of the patient. With a patient in the horizontal position on the treatment couch, the body contours were more consistent than when a patient was rolled from side to side. When a patient was upright, the contours often became quite distorted and variable. Results from theoretical computer programs were compared with calculations done in the usual manner. The results showed that a correct pattern could be produced within 1%. A mathematical relation to express the tumor depth in terms of the patient's width, thickness, anterior tumor depth, desired weekly dose, and relative tumor size was developed and presented. All tables, charts, and graphs necessary to complete the calculations were retained in computer storage. The computer provided the patient's name, width, thickness, anterior tumor distance, port size, and calibration information on the $^{60}Co$ source. The time consumed in making repetitive laborious calculations was markedly reduced, and errors were eliminated. (BBB)

**14497** ESTIMATES OF ABSORBED FRACTIONS FOR MONOENERGETIC PHOTON SOURCES UNIFORMLY DISTRIBUTED IN VARIOUS ORGANS OF A HETEROGENEOUS PHANTOM. Snyder, W. S. (Oak Ridge National Lab., Tenn.); Ford, Mary R.; Warner, G. G.; Fisher, H. L. Jr. J. Nucl. Med.; 10: Suppl. No. 3, 7-52 (Aug 1969).

The estimation of absorbed dose in various organs from a source of photons within the body is complicated by the complex geometrical structure and inhomogeneities of the body; it is also complicated by the fact that estimates involving only the interactions of the primary photons generally are not sufficiently accurate. The absorbed fraction, $\phi$, designates the fraction of photon energy emitted from the source organ that is deposited in the target organ. The absorbed fraction can be expressed as $\phi$ = photon energy absorbed by target/photon energy emitted by source. Estimates of the absorbed fractions of photon energy deposited in various organs are given in what might be called the standard man approximation (that is, the method involves certain idealizations of an actual exposure situation). There are three principal idealizations. A phantom is used which has a simple geometrical shape and approximates the human body shape and dimensions as far as the major forms are concerned but which neglects minor features; the same applies for the 22 internal organs defined as subregions of the phantom. Each organ defined within the phantom is considered to be homogeneous in composition and density, although different compositions and densities are used for the skeletal region, lungs, and the remainder of the phantom. The phantom is described in detail. The source is considered to be monoenergetic and uniformly distributed within one of the organs. The Monte Carlo method is used to obtain histories of photons that originate within the source organ; the interaction sites within the phantom are determined in accordance with the mass-attenuation coefficients. Energy is assumed to be absorbed locally at the interaction sites except for energy carried by photons scattered by the Compton process

or photons produced by annihilation of a positron produced by the pair-production interaction. Data are presented on the absorbed fractions, $\phi$, for some 25 target organs tabulated for 12 monoenergetic photon sources uniformly distributed in each of 16 source organs. A standard deviation of each estimate is computed which in some instances is almost as large as the estimate. In such cases the estimate must be considered as unreliable. In these cases the absorbed fraction is invariably low, indicating that the absorbed dose to the organ is a small fraction of the absorbed dose to the source organ. (C.H.)

**14498** FAST NEUTRONS: LET DISTRIBUTIONS AND THE RESPONSE OF MAMMALIAN CELLS. Bewley, D. K. (Hammersmith Hospital, London). pp 65-86 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

Distributions of stopping power (LET) are given for four beams of fast neutrons, namely, neutrons of 14.6 MeV, neutrons produced by bombarding a thick beryllium target with 15 MeV deuterons, neutrons of 3 MeV, and fast neutrons produced by bombardment of a $^{235}U$ converter plate with thermal neutrons. The track average LET is correlated with mean neutron energy, but the dose average is approximately constant. However, neither of these types of average is expected to have much relevance to radiobiology. Further, specification of a biologically effective LET depends on the biological test used, and is not solely a function of the radiation quality. An attempt has been made to calculate the response of T1 kidney cells in tissue culture to these four beams of neutrons, based on their response to charged particles using the track-segment method. The calculated RBE's of the neutron beams are lower than the observed values and the calculated values of the oxygen enhancement ratio are higher. These differences seem too great to be explained by errors in dosimetry and in the calculated LET spectra. The suggestion is made that LET is not an adequate criterion of radiation quality, and that the discrepancies may be explained by more detailed consideration of the part played by delta rays and by heavy recoil tracks of short range. (auth)

**14499** MICRODOSIMETRY AND THE THEORY OF STRAGGLING. Kellerer, A. M. (Univ., Munich. Gesellschaft fuer Strahlenforschung, Neuherberg, Ger.). pp 89-103 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

Theoretical developments in microdosimetry (the determination of the spatial distribution of energy deposition on a microscopic scale) are described. It is pointed out that microdosimetric theory is equivalent to LET theory plus straggling theory. The influence of each of the different random factors (varying LET, varying track length, varying number of primary collisions and varying energy transferred in primary events) can be expressed as a relative variance and these relative variances can be summed to give the relative variance of the single-event spectrum. The track-length-variation and the variation in the number of primary events will often not be important. Although the LET variation may be quite important, it appears that the energy spectrum of primary collisions will usually make the decisive contribution. (auth)

**14500** COMPARISON OF LET AND EVENT-SIZE DISTRIBUTIONS. Cormack, D. V. (Univ. of Saskatchewan, Saskatoon). pp 105-13 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

Event-size distributions, P(Y), corresponding approximately to those measured by Rossi, were calculated for $^{60}Co$ from the calculated LET distributions, using various simplifying assumptions. For a cut-off energy, $\Delta$, of 100 eV the P(Y) distribution is markedly different from the LET distribution, pointing out the inadequacy of the latter as a description of radiation quality. Comparison of the calculated P(Y) distribution with measured data for a 1 $\mu$m diameter sphere showed fair agreement, although the calculated curve was shifted to lower values of Y. (auth)

**14501** COMMENTS ON SOME PHYSICAL PARAMETERS CHARACTERIZING RADIATION ABSORPTION. Booz, J. (EURATOM-CCR, Ispra, Italy). pp 115-23 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

It is shown that three parameters are necessary to characterize energy absorption of a certain radiation in small volumes: the shape and size of the volume, its cross-section to the radiation in question, and the absorbed energy. The cross-section in relation to the radiation is bigger than the geometrical cross-section because of $\delta$-ray production. Measurement of the radiation-defined cross-section and its relation to the geometrical cross-section is proposed. A new measure describing the absorbed energy is defined which is based on the mean local energy density and is called Linear Energy Absorption (LEA). It is shown that the LEA is equal to the track length averaged LET for any volume shape, if the ionizing particles are ideally straight lines crossing the volume. In cases where this idealization does not hold, the LEA is, in general, bigger than the track length averaged LET and gives the correct value for the mean energy absorbed inside the volume per unit length. The LEA should therefore be used as the biologically significant average of LET spectra. (auth)

**14502** DETERMINATION OF RADIATION QUALITY BY USE OF RECOMBINATION METHODS. Zielczynski, M. (Inst. of Nuclear Research, Swierk, Poland). pp 125-34 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968). (In Russian).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

The quality of radiation, considered from the standpoint of its biological influence, is determined by the spatial and time distribution of energy imparted to tissues. One of the main parameters of the microscopic spatial energy distribution is the linear energy transfer (LET). The recombination methods, developed in recent years, make it possible to measure the LET value, averaged after a given relation, and particularly to estimate the quality factor (QF) of mixed radiation having any spectrum and composition. The relation of the recombination process with the magnitude and direction of an electric field and with gas pressure and time is used to select the corresponding performances of a recombination detector. With the application of the appropriate method it is possible to determine QF and other parameters related to LET, in various circumstances. (auth)

**14503** SIMULTANEOUS DETERMINATION OF $^{59}Fe$, $^{51}Cr$, AND $^{125}I$ ACTIVITY IN MIXED SAMPLES. Harper, John W.; Green, James F.; Logsdon, Donald F. Jr. (School of Aerospace Medicine, Brooks AFB, Tex.). Radiol. Technol.; 41: 244-8(Jan 1970).

The simultaneous measurement of erythrokinetics with $^{51}Cr$, ferrokinetics with $^{59}Fe$, and blood volume with $^{125}I$ leads to samples containing a mixture of all three radioisotopes. A simple approach to the determination of the radioactivity of the individual radioisotopes in the mixture, based on the determination of counting windows for each radioisotope is presented. (auth)

**14504** DOSIMETRIC EVALUATION OF THIRTY DENTAL FACILITIES IN MASSACHUSETTS. MEASUREMENT OF WORKLOAD RELATED TO EXPOSURE TO ENVIRONS. Kline, A. Burt Jr. (Dept. of Health, Education, and Welfare, Rockville, Md.); Stewart, Harold F.; Wellock, William; Maitland, Alexander. Oral Surg., Oral Med., Oral Pathol.; 29: 44-58(Jan 1970).

Workloads of dental x-ray machines were successfully measured by two independent techniques. Because of decreased cost and increased ease of use, the capsule is considered more advantageous than the disk as a method for workload monitoring. In general, the results indicate that workload measurements and the associated exposure levels generated to the environs, gonads, etc., can be obtained in an accurate, reliable, and practical manner (for health physics purposes) through the use of thermoluminescent dosimeters in the manner described. (auth)

**14505** FACTORS RELATING TO THE APPLICATION OF RADIOISOTOPES TO CIRCULATORY-SUPPORT SYSTEMS. Cole, Donald W.; Mott, William E.; Sagan, Leonard A. (Atomic Energy Commission, Washington, D. C.). Isotop. Radiat. Technol., 7: 138-45(Winter 1969-70).

The U. S. Atomic Energy Commission (AEC) in cooperation with the National Heart Institute (NHI) of the National Institutes of Health is developing radioisotope power supplies for devices to assist or totally replace the human heart. In a radioisotopically powered artificial heart, heat from the decay of radioisotopes would be used to provide power for the operation of a blood pump. Radioisotope power sources offer the advantages of being completely implantable and of having a relatively long life. Initially, conceptual designs of radioisotope heat engines were developed, candidate radioisotopes fuel forms evaluated, and the radiation doses to be expected from the various fuel forms studied. Conceptual-design studies indicate that a power supply capable of meeting the specifications of a circulatory-support system can be developed. The optimum fuel is $^{238}Pu$. Radiation damage does not appear to be a problem. (auth)

**14506** $^{238}Pu$ FOR BIOMEDICAL APPLICATIONS. Mullins, L. J.; Leary, J. A. (Los Alamos Scientific Lab., N. Mex.). Isotop. Radiat. Technol., 7: 197-207(Winter 1969–70).

The successful utilization of $^{238}Pu$ as a biomedical radioisotopic power source requires that the external radiation of $^{238}Pu$ be understood quantitatively and kept to a minimum. To achieve these objectives, $^{238}Pu$ metal (80 at.% $^{238}Pu$) of high chemical purity was prepared and characterized. An electrorefining process was developed to prepare the metal on a 1-$cm^3$ scale. The neutron-emission rate of three lots of electrorefined metal was 2446 (±30) n/(sec) (g of Pu). Correcting this measured rate for chemical impurities and fast fission gives a spontaneous fission rate of 2234 n/(sec) (g of Pu), or 2800 n/(sec) (g of $^{238}Pu$). Neutron and gamma dose rates were also measured. $^{238}Pu$-gallium alloy, $^{238}PuO_2$, and $^{238}PuN$ were prepared and evaluated as radioisotopic heat sources. (auth)

**14507** IN-PHANTOM DOSIMETRY OF $^{147}Pm_2O_3$ HEAT SOURCES IN RELATION TO CIRCULATORY-SUPPORT SYSTEMS. Cross, F. T. (Battelle-Northwest, Richland, Wash.); Sheppard, J. C. Isotop. Radiat. Technol., 7: 231-40(Winter 1969–70).

The in-phantom predictions and measurements on two cylindrical $^{147}Pm_2O_3$ radioisotopic heat sources of nominal 15-watt rating and containing 0.25 and 3.5 ppm $^{146}Pm$ impurity are presented. The protocol for characterizing the dose-rate fields is discussed. A comparison of two computer codes is included, the conclusion being that the more versatile QAD code is somewhat more accurate in predicting the measurements and, in fact, is capable of predicting the phantom measurements to within the experimental error of ± 20%. If the total source-shield weight is restricted to about 0.5 lb, the $^{146}Pm$ impurity would need to be reduced to an order of magnitude or to about 0.02 ppm for promethium heat sources to be competitive with the estimated dose rates from electrorefined $^{238}Pu$ heat sources. This comparison is for a promethium heat source of twice the thermal rating of a plutonium heat source. For a total source-shield weight of 1.2 lb (the full complement of shields utilized in the phantom measurements), the 0.25 ppm $^{146}Pm$ source produced dose rates at 20 cm into tissue (the approximate location of the spleen if the source is placed on the left ilium) of about 35 mrems/hr. This could be reduced to about 20 mrems/hr by rotating the source 90° and taking advantage of the dose reduction from source self-absorption. It is perhaps misleading to compare bare sources rather than sources placed within a blood-pump subsystem since it is recognized that a significant dose reduction takes place by distance shielding alone. The first tissues encountered by the radiations emanating from a subsystem would probably be at distances greater than those in contact with a bare source. This will reduce the source-surface dose rate and thus the integrated dose rate in the body. However, the dose to any one organ, like the spleen, may not change appreciably unless there is an interposed thickness of higher-atomic-number materials from the subsystems. A more logical comparison of promethium with plutonium would be the computation of dose rates accrued by tissue from sources placed within a subsystem. Once suitable prototypes are developed, this comparison should be made. (auth)

## *Radiation Protection*

*Refer also to abstracts 13823, 14128, 14139, and 14615.*

**14508** RADIATION PROTECTION IN HIP JOINT RADIOGRAMS IN SMALL CHILDREN IN DAILY OFFICE PRACTICE. Hofer, H. (Landeskrankenanstalten, Salzburg, Austria). Beitr. Orthop. Traumatol.; 13: 688-9(Nov 1966). (In German).

Radiation protection of the gonads of infants and small children during x-ray studies of the hip joint area was discussed. Factors that affected the position of the ovaries included the sizes and volumes of the bladder and intestines, and the mobility of the tubes. Generally, the ovaries in infants and children were found to be located higher than in adult females. Sometimes they were located asymmetrically, far to one side. Their mobility was greatest in newborn infants, and decreased during growth. During x-ray studies the position of the ovaries was first marked with small pieces of Pb. The first x ray was taken without displacing the ovaries. During the second and third x ray the ovaries were displaced maximally in the cranial and caudal directions, respectively. Using the symphysis and both superior anterior iliac crests as orientation points, a Pb rubber shield was found to be effective. A shield extending from the symphysis to the lower ½ of the pelvis was inadequate for infants, children, and adults. It was not feasible to use an elliptically shaped shield because it was impractical to attempt to attach it properly. For male infants and children 2 sizes of shields for the gonads were constructed. The smaller size was used for infants up to the age of 8 months, and the larger size for children up to 8 yr old. (BBB)

## *Safety Procedures*

**14509** (NYO-3394-11) FEASIBILITY STUDY OF THE CORRELATION OF LIFETIME HEALTH AND MORTALITY EXPERIENCE OF AEC AND AEC CONTRACTOR EMPLOYEES WITH OCCUPATIONAL RADIATION EXPOSURE. Progress Report No. 5, August 1, 1968–July 31, 1969. Mancuso, Thomas F.; Sanders, Barkev S.; Brodsky, Allen (Pittsburgh Univ., Pa. Dept. of Occupational Health). 31 Dec 1969. Contract AT-(30-1)-3394. 216p. Dep. CFSTI.

Progress is reported on a five-year study to test, in selected atomic energy installations, the predicted feasibility of carrying out an epidemiological investigation of the correlation of lifetime health and mortality data with occupational radiation exposure in AEC installations. The purpose of the ultimate study would be to ascertain empirically whether there were any lasting biological effects from radiation exposure received from employment in these installations since they came into operation. The feasibility of concluding a meaningful study with the available data has essentially been established. Except for some of the very early contractors, and the recent whole-body counting data, all radiation exposure records at Hanford and Oak Ridge, as well as personal data and sibling data from Hanford, have been abstracted and transferred to magnetic tape in suitable format. The personnel and sibling identification data at Oak Ridge have been abstracted and conversion to the magnetic tape file is now being completed. Personal and exposure data abstracting for the feed materials plants files that were shipped to Oak Ridge is now underway. Printouts of summary radiation exposure frequency distribution for Oak Ridge and Hanford are summarized. Additional summaries of occupational radiation exposure distributions at Hanford and comparisons between occupational radiation and medical x ray exposures at Hanford are also presented. The plans for the following years and current conclusions and recommendations are included. (C.H.)

**14510** EXAMINATION OF THE FECUNDITY OF THE RADIOLOGIST-PHYSICIANS. Czeizel, Endre; Bene, Eva. Magy. Radiol., 21: 243-9(Aug. 1969). (In Hungarian).

In order to clear the genetic harmfulness of ionizing radiation on the events of birth and the most important genetic pecularities of the descendants were examined in 755 radiologist-physicians and, for control, in 346 laboratory physicians. Significant difference was found in the domain of fecundity. The fecundity of the radiologist-doctoresses was significantly lower than the fertility of the doctoresses employed in laboratories and of the wives of radiologists. This phenomenon is thought to be due to the increased birth control of the radiologist-doctoresses, attributable to the roentgenophobia. (auth)

**14511** LIFE IN SPACECRAFT. Proceedings of the 18th International Astronautical Congress, Belgrade, 1967. Volume 4. Lunc, Michal (ed.). New York, Pergamon Publishing Company, 1968. 198p. (In several languages). (CONF-670989-(Vol.4)).

Separate abstracts were prepared for three papers presented at the conference. An additional 18 papers were presented on various aspects of space flight. (H.L.W.)

*For abstracts of individual papers see: 14512, 14513, and 14523.*

**14512** HUMAN PHYSIOPATHOLOGY IN FACE OF RADIATION AND HYBERNATION. Nieto, M. (Academia de Ciencias Medicas, Barcelona). pp 45-7 of Life in Spacecraft. Lunc, Michal (ed.). New York, Pergamon Publishing Co., 1968.

From 18th International Astronautical Congress, Belgrade, Yugoslavia. See CONF-670989-(Vol.4).

Radiation effects on Japanese fishermen following weapon detonations are studied. Because of similarities to cosmic radiation, the results are compared to radiation effects on astronauts during space flights. Chemically induced hypothermia and various enzymes are studied for their protective effects against cosmic radiation. (H.B.G.)

**14513** FURTHER STUDIES OF COMPLEX EFFECTS OF IONIZING RADIATION AND ACCELERATION ON ORGANISM DURING COSMIC FLIGHTS. Antipov, V. V.; Davydov, B. I.; Panchenkova, E. F.; Saksonov, P. P. pp 49-57 of Life in Spacecraft. Lunc, Michal (ed.). New York, Pergamon Publishing Co., 1968. (In Russian).

From 18th International Astronautical Congress, Belgrade, Yugoslavia. See CONF-670989-(Vol.4).

Data are presented on effects of radiation on the organism during cosmic flights. The principles of extrapolation of experimental data for man and data obtained on permissible doses of radiation under conditions of acceleration are analyzed. Experiments were

conducted with 1200 mice irradiated with γ or x rays at doses of 100 to 4000 rem (15 to 18 R/min) and exposed to 3 min of acceleration. Extrapolation of data for men exposed to 200 to 700 rem is given in curves showing the dose-time reaction to critical doses. The extrapolated data established that the exposure of men to 50 to 90 rem for 200 days does not disturb the normal reactions to acceleration. It was stressed that data obtained represent only a preliminary study of permissible doses for astronauts, and that other extreme factors of flight should be considered. (R.V.J.)

**14514** MEDICAL ASPECTS OF AEROSPACE FLIGHT. Vishwanathan, R. J. Ass. Physicians India; 16: 95-112(Feb 1968).

The possible deleterious effects on humans of ionizing radiation and other factors are reviewed in relation to manned space flight, with 38 references. Space radiation of two types, solar and cosmic, is considered. The sun radiation is composed of various forms from soft x rays up to radiowaves of over 10-m wavelength. Cosmic radiations include higher energies, and can cause local areas of intense tissue damage. The primary and secondary cosmic radiations are considered. The primary ones produce ionization tracks and nuclear damage. Such rays are usually restricted to altitudes of 70,000 ft or above. Below this height they are absorbed by the constituents of the atmosphere and undergo changes. These so-called secondary cosmic radiations are far less energetic than the primary ones. The high radiation zones, the Van Allen belts, are explained. These areas are found at altitudes of 24,000 to 50,000 Km and at 13,000 and 20,000 Km. The excessively high radiation fluxes in these zones pose new radiation problems for man in space flight. The effects can be minimized by rapid transit of these belts and adequate shielding. (BBB)

**14515** ALKALINE HEMOLYSIS OF ERYTHROCYTES OF MINERS IN URANIUM MINES. Nosek, J.; Bartonova, H. Cas. Lek. Cesk., 108: 78-81(Jan. 1969). (In Czech).

In a control group and a group of miners from uranium mines the alkaline hemolysis of red blood cells heated in a water bath of 55°C was investigated. Alkaline hemolysis took a more rapid course in the group of miners. Experimental evidence that traces of uranyl salts and lead salts promote alkaline hemolysis of red blood cells was given. (auth)

### Legal Aspects

*Refer also to abstract 14242.*

**14516** THE LEGAL STATUS OF RADIATION PRESERVATION OF FOODS IN THE WORLD. Diehl, J. F. (Bundesforschungsanstalt fuer Lebensmittel-Frischhaltung, Karlsruhe, Ger.). Z. Lebensm.-Untersuch. Forsch.; 138: 61-70(1968). (In German).

The present legal regulations pertaining to radiation preservation of foods in several countries were summarized, including those of Belgium, Denmark, West Germany, East Germany, France, England, Italy, Israel, Canada, Luxembourg, Netherlands, Austria, Switzerland, Russia, Spain, and the United States. The most detailed regulations for radiation preservation published have been issued in the United States. These regulations require that the irradiated food must be wholesome; the irradiation must be effective; the irradiation used must not exceed the minimum dose required; no measurable induced radioactivity is permitted; the technical irradiation procedures must be effective and safe even under large scale, simulated conditions; and the taste, odor, consistency, and appearance of the irradiated food product must be essentially unchanged. Foods, food products, and food packaging materials authorized for irradiation were tabulated. They included bacon, wheat and flour, potatoes, and various types of packaging materials irradiated with $^{60}Co$, $^{137}Cs$, x rays, or 5- and 10-MeV electrons, at doses ranging from 0.005 to 6 Mrad. (BBB)

## Medicine

*Refer also to abstracts 14193–14200, 14506, and 14510.*

**14517** ANALOG COMPUTER AS A TRAINING AID IN NUCLEAR MEDICINE. Spencer, Richard P. (Yale Univ., New Haven). J. Nucl. Med.; 10: 660(Oct 1969).

Kinetic studies are of increasing importance in nuclear medicine; compartmental interchange and radiodecay can be described by simple differential equations that can be solved by an analog computer with a graphic display. Therefore, for training purposes, nine simple model programs have been developed. Included are such things as first-order decay, double radionuclides, three-compartment distribution model, and combined flow and decay, among others. Copies of the programs can be obtained from the author. (C.O.)

### Protective Substances

*Refer also to abstracts 14426, 14438, 14512, 14570, and 14573.*

**14518** DIFFERENTIAL CHEMOPROTECTION OF NORMAL AND MALIGNANT TISSUES. Yuhas, John M.; Storer, John B. (Jackson Lab., Bar Harbor). J. Nat. Cancer Inst., 42: 331-5 (Feb. 1969).

The radioprotective agent, WR-2721 (S-2-[3-aminopropylamino] ethylphosphorothioate), was tested for its ability to protect mice against x-ray-induced lethality and against x-ray-induced skin ulceration, and for its ability to protect a transplantable mammary tumor against radiation-induced inhibition of transplantability. Injection of WR-2721 (500 mg/kg) 15 minutes before x ray exposures increased the dose required to induce 50% lethality within 30 days (LD50/30) by 160 to 170%, increased the x ray dose required to induce skin ulceration in 50% of the mice by 140%, but increased the dose required to inhibit tumor transplantability by only 15%. This differential protective activity, even though limited in scope, should be investigated further to assess the potential usefulness of radioprotective agents in radiotherapy. (auth)

**14519** KINETICS OF MICRONUCLEI OF THE KIDNEY AFTER IRRADIATION AND UNILATERAL NEPHRECTOMY. EFFECT OF CYSTAMINE. Smoliar, V. (Univ., Liege). Int. J. Radiat. Biol.; 16: 227-31(1969). (In French).

After whole-body irradiation with 700 R, pathological micronuclei gradually accumulate in the tubules of the rat kidney, with a maximum value and a plateau 6 weeks after irradiation. The same palteau is reached much faster if the cell proliferation of the tubules is stimulated by a contralateral nephrectomy at any time between 1 hour and 13 weeks after irradiation. When cystamine is given before irradiation, the evolution of the micronuclei is similar, but their number is in all cases 50 per cent lower than in the non-protected animals. In the present experiment, it was not possible to detect any recovery of the damage responsible for the production of micronuclei. (auth) (UK)

**14520** MARROW INFUSIONS IN DOGS GIVEN MIDLETHAL OR LETHAL IRRADIATION. Thomas, E. D.; LeBlond, R.; Graham, T.; Storb, R. (Univ. of Washington, Seattle. Public Health Service Hospital, Seattle). Radiat. Res.; 41: 113-24 (Jan 1970).

The question of harmful or beneficial effects of allogeneic marrow infusions was studied in dogs given 400, 500, or 600 R of whole-body irradiation from opposing $^{60}Co$ sources. After 400 R, one of five dogs not given marrow survived while two of five given allogeneic marrow survived. Ten dogs were given 500 R and five received allogeneic marrow and, similarly, 10 dogs were given 600 R and five were given allogeneic marrow. All animals in both groups died. A comparison of survival times, white blood cell and platelet counts, and marrow histology at all three radiation exposures showed no difference in the animals given marrow and the controls. Three dogs given 400, 500, or 600 R, followed by infusion of their own marrow, removed before irradiation, recovered promptly and survived. It was concluded that in this outbred species, allogeneic marrow given after midlethal or lethal irradiation is neither harmful nor beneficial. On the other hand, autologous marrow is effective in protecting against death in these animals. Genetic factors controlling histocompatibility differences appear to be of major importance in determining the outcome of marrow transplantation attempts in the 400 to 600 R range. (auth)

**14521** MODIFICATION OF RADIATION INJURY IN BLOOD, BONE MARROW, AND SPLEEN BY LONG-TERM POSTIRRADIATION HYPOXIC HYPOTHERMIA. Praslicka, M.; Marko, L.; Horak, J. (Safarik Univ., Kosice, Czech.). Radiat. Res.; 40: 490-502(Dec 1969).

The effect of hypoxic hypothermia was investigated in mice at a body temperature of 25 to 30°C and atmospheric pressure of 250 to 300 mm Hg for 5.5 days after irradiation. These conditions shorten the mean survival time and increase the loss in body weight of irradiated animals. These conditions also delay the decrease in neutrophils and, to a lesser degree, the decrease in peripheral lymphocytes and erythrocytes as well as all elements of the bone marrow and spleen. A delay in the development of reparative processes in the germinal centers of splenic lymphatic nodules was also noted. During the first three days of hypoxic hypothermia bone the marrow and the spleen red pulp show an increase in the mitotic index. Hypoxic hypothermia stimulates ectopic erythropoiesis in the spleen red pulp in irradiated

as well as nonirradiated animals. In irradiated animals the stimulation occurs particularly within the first 48 hours after irradiation. Symptoms of a lasting favorable effect of hypoxic hypothermia on the reparative processes in erythropoiesis will require further investigation after sublethal doses of irradiation. (auth)

**14522** STUDIES OF THE PROTECTIVE EFFECT OF GERMANIN AGAINST CHEMICAL AND PHYSICAL STIMULI IN AMOEBA SPHAERONUCLEOSUS GREEFF USING TIME TRANSFORMATION (FAST-MOTION EFFECT). Horstmann, Lore-Marie (Johann-Wolfgang-Goethe-Univ., Frankfurt am Main). Arch. Protistenk., 111: 38-81(1968). (In German).

Protective effects of Germanin, m-aminobenzoyl-m-amino-p-methyl benzoyl-1-naphthylamine-4,6,8-trisulfonate, against uv irradiation at 253.7 nm were studied in Amoeba sphaeronucleosus. The organisms lost their reproductive capability completely after being uv irradiated for five to 15 min. The cells clumped together during irradiation. The pulsating vacuole became very large, and multiple vacuoles were observed. No movement or cell divisions were observed, after the survival of the amoeba was markedly shortened. After 24 hr most of the amoeba were dead, and the surviving amoeba exhibited nuclear enlargement and vacuolization of the karyosomes. The pellicles and nuclear membrane were thickened. In cultures pretreated with 0.1% Germanin solutions, after irradiation the pulsating vacuole became enlarged, but emptying frequency was normal. After 24 hr about 10% of the amoeba had died, and cell divisions were not observed. The main effect of the Germanin treatment was to increase survival. Survival was increased by 20% in the amoeba irradiated for five min, and by 40% in the amoeba irradiated for 10 or 15 min when the cultures were pretreated with Germanin. (BBB)

**14523** GASTRIC SECRETION IN CATS AFTER INTENSIVE IRRADIATION CONNECTED WITH PREVIOUS AND SIMULTANEOUS HYPOXIA. Kaulbersz, J.; Barylak, A.; Radecki, T. (Academy of Medicine, Krakow). pp 71-3 of Life in Spacecraft. Lunc, Michal (ed.). New York, Pergamon Publishing Co., 1968. From 18th International Astronautical Congress, Belgrade, Yugoslavia. See CONF-670989-(Vol.4).

Ten cats with gastric fistulas and plastic spools inserted into the stomach were given 650 R of x radiation. Secretion of gastric juice was stimulated by histamine dihydrochloride. The animals were placed in a low pressure chamber 24 hr before irradiation. Gastric juice was examined at intervals up to 18 days after irradiation. Results indicated a decrease of HCl and a protective effect of hypoxia. (H.L.W.)

**14524** EXPERIMENTAL RESULTS ON THE VALUE OF THE COMBINED TREATMENT OF GAS GANGRENE IN IRRADIATED ANIMALS. Chelemen, N. (Central Military Hospital, Bucharest); Bittner, J.; Ardeleanu, Judith; Grigoresco, St.; Bonciocat, N.; Ghimpu, P. Rev. Int. Serv. Sante Armees Terre Mer Air; 42: 467-74(Jun 1969). (In French).

Both the prophylactic and therapeutic action of antitoxic serum alone or associated with Semisint (semisynthetic penicillin) or with ethylenediaminetetraacetate (EDTA), or with both used together, was studied in more than 2300 RAP mice infected by Clostridium perfringens, type A, after irradiation by a 350 R dose of 200 KV x rays. The animals were irradiated 24 or 96 hr before infection and treated with 1 or 20 antitoxin units (AU) of antiserum to C. perfringens, 500 or 1000 international units (IU) of Semisint, and/or 5 mg of EDTA. Of the different schemes of treatment used, the best were: 20 AU of antiserum + 1000 IU of Semisint (scheme 4), and 1 AU of antiserum + 5000 IU of Semisint + 5 mg EDTA (scheme 8). The first combination afforded the irradiated animals a protection of 80.6% after the prophylactic treatment (1 hr) and 47.9% after the therapeutic treatment (3 hr). The second combination gave 71.4% and 37.4% protection, respectively. There were no significant differences between these two schemes ($p = 0.05$). These protective results were obtained without any surgical intervention at the location of the gangreneous infection. Use of Semisint considerably improved the efficiency of the therapeutic schemes. This treatment was very effective when the period between infection and the treatment was 1 hr. The results were even better when this period was shorter. (BBB)

**14525** HYBERBARIC OXYGEN AND RADIOTHERAPY: CLINICAL EXPERIENCES. Churchill-Davidson, I. (St Thomas' Hospital, London). Nunt. Radiol.; 34: 215-25(Mar 1968).

Evolution of high-pressure oxygen techniques, used to sensitize tumor cells tc radiotherapy, is traced, and results of the early and late methods are reported. The present dose 3600 R (3500 rad) in 6 treatments over 18 to 19 days is a maximum tissue dose, with air-gap-compensating filters being used when necessary. Most patients are now treated conscious, breathing oxygen at 3 atm absolute. In both conscious and anesthetized patients, a period of 15 min at full pressure is allowed for the tumor to saturate with oxygen before starting treatment. After a preliminary trial in 1955 in which half the tumor was irradiated in air and the other half irradiated in hyperbaric oxygen, when it was possible to show more histological damage in the half irradiated in oxygen, a trial was started in which attempts were made to cure patients whose tumors, although at the time without distant metastases, were considered too locally advanced to have a chance of cure by conventional radiotherapy. This was the criterion of selection for all cases, 311 patients irradiated in hyperbaric oxygen and 99 patients in air. As expected when patients with such advanced local disease were selected, the distant metastasis rate was high, but similar for patients irradiated in oxygen and air. More patients treated in oxygen subsequently developed a second primary tumor, but this was probably due to their having lived longer. The number of cases surviving without recurrence at periods after treatment of up to 11 yr in the oxygen series and 9 yr in the control series is reported and discussed. (BBB)

**14526** AXON GROWTH THROUGH IRRADIATED MEDIAN AND ULNAR NERVE HOMOGRAFTS IN PRIMATES. Ashley, Franklin L.; Murphy, J. E.; Morgan, S. C.; Balch, C. R.; Conover, W. A.; Galloway, D. V.; Cross, L. (Univ. of California, Los Angeles). Plast. Reconstr. Surg., 42: 313-21(Oct. 1968).

Irradiated tendon homografts exhibited excellent healing and minimal inflammatory reaction, and were superior to nonirradiated tendon homografts. Thirty-seven peripheral nerve grafts were performed in 15 adult primates; 11 Rhesus monkeys (Nemostrinas) and 4 Japanese apes (Lysodes fuccada) were used. Thirty-three irradiated homografts and 4 autografts were placed in the upper limbs. The irradiation of the grafts consisted of 1.5 Mrad of $^{60}Co$ $\gamma$ rays. Segments of the median and ulnar nerve in the upper arm and forearm were excised and replaced with a graft of appropriate length. Minimal scarring was present on initial surgical exposure of the grafts; on later surgical exposures, marked fibrosis and shortening of the grafts were observed. A recurrent or third neuroma was produced on six occasions. Serial electromyographic studies demonstrated a return of voluntary motor activity in all denervated forearm muscles and all denervated intrinsic hand muscles, with the exception of four cases. Nerve conduction velocities returned to normal or near normal values in all but three grafts, which were long irradiated homografts. Microscopic examination revealed axons distal to the graft in all but one nerve. About 75% of the axons appeared to cross the short (1.5 cm to 3.0 cm) grafts, whereas 40% or more traversed the long (7.0 cm to 11.5 cm) grafts. Gross, electrical, and histologic evidence indicated that axons will grow through irradiated nerve homografts, up to 11.5 cm in length. (BBB)

**14527** INFLUENCE OF SULFUR-CONTAINING RADIOPROTECTORS ON THE INTRASPLENIC OXYGEN TENSION IN THE RAT. Lelievre, P.; Smoliar, V.; Betz, E. H. (Univ., Liege). Atomkernenergie, 14: 445-7(Nov.-Dec. 1969). (In German).

The variations of the intrasplenic oxygen tension and of the respiratory quotient were measured in rats treated with cystamine, cysteamine or cysteine. Cystamine decreases the oxygen tension which reaches a minimum 10 min after injection; the hypoxia persists up to the 45 min and then diminishes. Cysteamine has a similar effect; however the drop of the oxygen tension is less marked and occurs later. Cysteine has practically no effect on the oxygen tension in the spleen. The injection of sulfur-containing protectors induces an increase of the respiratory quotient. Cystamine is more active than cysteamine; cysteine has no effect. In rats starved during 72 hours, the same response is observed after administration of the substances under investigation. It is likely that the variations of the respiratory quotient are related to the tissue anoxia and acidosis induced by cystamine and in a lesser degree by cysteamine. The anoxia could explain the greater protective effectiveness of cystamine in the rat. However anoxia is not the only factor involved in the protective action of the sulfur-containing radioprotectors. (auth)

**14528** TRANSPLANTS OF MEDULLARY, LYMPHOID, AND THYMIC CELLS INTO LETHALLY IRRADIATED MICE. Delerz, M.; Haot, J. (Univ., Liege). Compt. Rend. Soc. Biol., 162: 2038-41(1968). (In French).

After lethal x irradiation, followed by injection of marrow cells, the hematopoietic restoration takes place without transitory accumulation of lymphoid cells in the bone marrow. Even if the marrow is exhausted by repeated regenerations, the animal can still survive lethal doses, provided it receives in addition to marrow cells also lymph node cells. The question arises whether the addition of lymphocytes or thymus cells to the marrow cells changes the action of the marrow lymphoid cells in such manner as to make regeneration and survival possible. To answer this question the variation of cell populations in the bone marrow of lethally irradiated mice was studied after they had received by

intravenous injection a suspension of either marrow cells alone or a mixture of marrow cells with either lymph node or thymus cells. Two and one half month old males were irradiated with a dose of 850 Rad and then separated into three groups: the first received marrow cells alone; the second marrow plus lymph node cells; the third marrow plus thymus cells. For each animal the hematocrit, and the count of leukocytes and of nucleated cells in the bone marrow of the femur were determined over a period of 24 days. The differential count of the stained marrow cells revealed first a rapid depletion of the principal cell types and then a regeneration of both erythroid and lymphoid cells. A comparison of the three groups revealed no effect of an addition of lymph node or thymus cells to the marrow cells. In particular this addition did not bring about any greater increase of lymphoid cells in the bone marrow than the administration of marrow cells alone. (F.J.W.)

## Radiodiagnosis

*Refer also to abstracts 14187, 14387, 14388, 14407, 14410, 14489, 14493, 14503, 14504, 14508, and 14607.*

**14529** RADIONUCLIDE CAROTID BLOOD FLOW EVALUATION WITH THE GAMMA-RAY SCINTILLATION CAMERA. Rosenthall, L. (Montreal General Hospital). J. Can. Ass. Radiol.; 20: 255-8(Dec 1969).

Four years' experience of carotid blood flow studies, using serial scans following an antecubital vein injection of radiopertechnetate, has shown this technique to be of qualified usefulness. It is recommended that at least 15 millicuries of radiopertechnetate be used and a maximum of 2-second exposure serial scans be obtained. Only the scan showing the initial entrance on the bolus of activity is reliable, as the jugular venous return may not be symmetric. The presence of the vertebral artery which is immediately adjacent to the carotid artery, and not resolvable, may obfuscate detection of a stenosed or occluded carotid artery. Reflux of the jugular and/or neck veins may on occasion invalidate the examination. A reduced carotid flow may be caused by stenosis or obstruction in the middle cerebral, internal carotid, or common carotid arteries. (auth) (Canada)

**14530** THE ABSORPTION OF $^{59}$Fe IN WOMEN WITH A LATENT IRON DEFICIENCY. Petrov, V. N.; Smirnov, B. I.; Shapiro, E. L.; Shcherba, M. M. (Scientific Research Inst. of Radiation Protection, Leningrad). Med. Radiol.; 12: No. 12, 17-20(Dec 1969). (In Russian).

A whole-body counter was used to investigate $^{59}$Fe absorption in 25 women, 13 of whom had clinical and biochemical indices of iron deficiency, while in 12 cases, a normal iron metabolism was observed. In all women, the blood concentration of hemoglobin exceeded 12 gm/% (absence of anemia). The percentage of absorption in persons with low iron supply was 3.5 times higher than in women with a normal iron content (23.8 and 8.38% correspondingly). There was found a direct relation between the concentration of protein siderofilin in the blood and the percentage of iron absorption ($r = 0.6$), and a reverse relation between the latter and the quantity of leukocytic cytochrome oxidase ($r = 0.62$). The results indicate the role of iron deficiency in the regulation of its absorption in the gastrointestinal tract. Whole-body counters may be used for the diagnosis of hypoferric conditions. (auth)

**14531** CEREBRAL SEQUENTIAL SCINTIGRAPHY. RESULTS IN 208 PATIENTS. Roesler, H.; Huber, P. (Univ., Bern). Fortschr. Geb. Roentgenstr. Nuklearmed.; 111: 467-80(Oct 1969). (In German).

Cerebral scanning with $^{99m}$Tc-pertechnetate is carried out in three stages. The first stage (radioangiography) consists of individual scans at four second intervals and registers the passage of the intravenously injected radioactive bolus through the cerebral circulation. The second stage, the vascular brain scan, is obtained five minutes after the injection and defines the differential distribution of blood in the skull. The third stage, the commonly used cerebral scan, was obtained after thirty minutes. This demonstrates focal abnormalities of the blood-brain barrier resulting from localized cerebral lesions. Stages 1 and 2 must be obtained with a scintillation camera. Typical findings in intracranial tumors and cerebro-vascular abnormalities are described. Two hundred and eight patients are examined in this way; in 107 angiography or air encephalography is carried out in addition. Scanning improved the diagnosis in 40%. The addition of stages 1 and 2 improved the diagnosis in 56% of patients with an abnormal brain scan. (auth)

**14532** CLINICAL STUDIES AND ANIMAL EXPERIMENTS CONCERNING RESORPTION OF DIES AND COLLOIDAL RADIOACTIVE GOLD BY THE COLON. D'Addabbo, A.; Dammacco, F.; Capurso, A.; Damato, V. (Univ., Bari, Italy). Fortschr. Geb. Roentgenstr. Nuklearmed.; 111: 565-72(Oct 1969). (In German).

Enemas containing a mixture of Evans' blue, lidocaine and colloidal radiogold ($^{198}$Au) were given to three patients suffering from enteropathy and to five control subjects. Scintigrams were made of the colon, and the concentration of the dye was determined in serum samples at various time intervals. The scintigrams showed irregular distribution of the radioactivity along the colon, diffuse scattering of the radioactivity in the abdomen, and some radioactivity in the liver area. Experimental enteropathy was provoked in rats by subcutaneous injections of hexadecylammoniumstearate. After application of Evans' blue enemas the serum of the enteropathic rats contained significantly more dye than the control serum. (auth)

**14533** COUNTING IODINE- AND SELENIUM-LABELED COMPOUNDS IN ONE SAMPLE. Myhill, John (Univ. of Sydney, Royal North Shore Hospital, Sydney). J. Nucl. Med.; 10: 46-8 (Jan 1969).

The effects of counting statistics and high-voltage drifts on the $\gamma$-counting of $^{125}$I and $^{75}$Se in the same sample were studied. It was concluded that a brass filter is usually preferable to pulse-height analysis for measuring $^{125}$I in the presence of $^{75}$Se (or, by extension, in the presence of $^{131}$I or $^{51}$Cr). (auth)

**14534** SELECTION OF POLAROID FILM FOR SCINTIPHOTOGRAPHY. Harbert, John C.; Ashburn, William L. (National Inst. of Health, Bethesda, Md.). J. Nucl. Med.; 10: 127-32 (Mar 1969).

Four polaroid film types were tested for use for scintiphotography using the Anger scintillation camera or a rectilinear scanner with cathode-ray tubes. It was concluded that film speed, at least over the 75 ASA to 10,000 ASA range is not a crucial factor in film selection for static scintiphoto studies. Slower films require a lower f-stop to admit more light and/or increased CRT beam intensity. However, increasing the intensity with slow film does not make the dots larger or result in loss of resolution. High-contrast film with a multiple f-stop lens cluster appears to be the best image recording system for organ visualization. At present, Type 51 is supplied only in the $4 \times 5$ format. It is expensive and far less convenient than the $3\frac{1}{4} \times 4\frac{1}{4}$ film packs. The latter are essential for rapid hand-pulled studies such as cardiac blood flow and are currently supplied only in the low-contrast, high-speed, Type 107 film. Until the high-contrast film is supplied in another format, it will probably not invite wide use. With television contrast enhancement for occasionally ambiguous scintiphotos, Type 107 film was quite satisfactory. (C.H.)

**14535** COMPARISON OF METHODS FOR RENOGRAM EVALUATION. Meade, Robert C.; Horgan, James D.; Madden, Joseph A. (Veterans Administration Center, Wood, Wis.). J. Nucl. Med.; 10: 40-5(Jan 1969).

Sixty-eight normal and 104 abnormal radioisotope renograms were evaluated according to 19 individual kidney parameters and 11 ratios of one kidney to the other. Good agreement was obtained with normal values of other authors for parameters which were not dose dependent. In general, the greatest diagnostic accuracy was obtained for parameters dealing with the drainage phase of the renogram. The time to return to 50% of peak was 90% accurate in detecting both the normal and abnormal renogram. The ratios were of questionable value in detecting bilateral or unilateral abnormal renograms. The absolute differences between the two kidneys were likewise of little value in detecting abnormal renograms. In the hydrated, seated patient, it appears possible to evaluate accurately the renogram without standardized equipment or dose. (auth)

**14536** RARE EARTH NUCLIDES AS POTENTIAL AGENTS FOR SKELETAL IMAGING. O'Mara, R. E.; McAfee, J. G.; Subramanian, G. (State Univ. of New York, Syracuse). J. Nucl. Med.; 10: 49-51(Jan 1969).

Good skeletal images can be obtained on the Anger camera using certain radionuclides of the heavier lanthanons as chelates of HEDTA. With rectilinear scanning, slow scanning speeds and long collimators with thick septa necessary for high-energy gamma emissions need not be used. These nuclides are readily and cheaply produced in a nuclear reactor without significant radioactive impurities. Of the rare-earth nuclides evaluated, $^{153}$Sm and $^{171}$Er have physical characteristics best suited for imaging in man. Samarium-153 has the advantage of greater convenience because its half-life is 47 hr and it has higher efficiency with the Anger camera. Erbium-171 has the advantage of a lower estimated radiation dose and a higher ratio of external photons per disintegration. (auth)

**14537** CEREBROVASCULAR PERMEABILITY STUDIES IN CEREBRAL NEOPLASMS AND VASCULAR LESIONS: OPTIMAL DOSE-TO-SCAN INTERVAL FOR PERTECHNETATE BRAIN SCANNING. Tauxe, W. Newlon; Thorsen, Helen C. (Mayo Clinic, Rochester, Minn. Mayo Foundation, Rochester, Minn.). J. Nucl. Med.; 10: 34-9(Jan 1969).

Brain scans were performed in a series of patients at various intervals after injection of $^{99m}$Tc-pertechnetate. The optimal interval between injection and scanning seems to be at least 3 hr. Our data suggest that scanning at this time leads to the greatest accuracy in diagnosing the positive scans with the least number of false-positive and false-negative reports. A method of analyzing scintiscan data is presented. This is based on the derivation of ratios based on actual counting rates obtained from digitized computer-processed scintiscan matrices. (auth)

**14538** DISTRIBUTION AND SCINTIPHOTOGRAPHY OF A NEW LUNG-SCANNING AGENT, $^{99m}$Tc-MACROAGGREGATED THIONIN: STUDIES IN THE RODENT. Yeh, Shin-hwa; Delahay, Joan E.; Kriss, Joseph P. (Stanford Univ. School of Medicine, Palo Alto, Calif.). J. Nucl. Med.; 10: 117-21(Mar. 1969).

A method for synthesizing $^{99m}$Tc-macroaggregated thionine is described. Distribution and scintiphotography studies in the rat and rabbit indicate that intravenously injected $^{99m}$Tc-MAT has an initial pulmonary uptake of 90% with subsequent gradual clearance from the lungs and transposition mainly to the liver, spleen, and bone marrow. Hazard from radiation is considered to be low. Neither chemical toxicity nor hypersensitivity was observed in the rat and rabbit in the experiments designed. The amount which may be injected safely in humans is discussed. The results suggest a potential usefulness of the aggregate in clinical lung scintillography. In view of its simple preparation and the physical characteristics of $^{99m}$Tc, it should be a useful addition to the present lung-scanning agents. (auth)

**14539** PROBLEMS RELATED TO THE LEUKOCYTE LABELLING WITH $^{51}$Cr. Boccaccio, P.; Ponassi, A.; Morra, L.; Brema, F.; Armani, U.; Sacchetti, C. (Univ., Genoa). J. Nucl. Biol. Med.; 12: 141-5(Oct-Dec 1969).

Leukocytes labeled in vitro with $^{51}$Cr were used in normal subjects and in patients with untreated chronic lymphatic leukemia to study leukocyte survival in blood and the organ distribution of transfused cells. In all normal subjects the radioactivity curve of circulating leukocytes was biexponential, showing a first phase with rapid fall, followed by a slowly declining phase. In patients with chronic lymphatic leukemia the initial phase declines as in normal subjects but is shorter and the slow successive phase lasts longer. Some cases show pluriexponential curves. The surface radioactivity record in normal subjects excludes leukocyte sequestration in the examined organs, whereas, in patients with chronic lymphatic leukemia, a considerable splenic sequestration appears. The results obtained, the technical limitations, and the further possibilities of this technic are discussed. (auth)

**14540** THE EFFECT OF ARTIFICIAL PORTOCAVAL ANASTOMOSIS OR SPLENECTOMY ON HEPATIC AND PORTAL HAEMODYNAMICS IN CIRRHOTICS. Blaha, V.; Vosmik, J. (Postgraduate Medical Inst., Prague). Nucl.-Med.; 8: 232-41 (31 Oct 1969).

Using a modified method, the blood clearances of $^{198}$Au colloid and $^{131}$I-Rose Bengal were simultaneously examined and the ratio $k_{RB}/k_{Au} \cdot 100$ was determined in a group of 11 patients with severe liver cirrhosis, portal hypertension, and portosystemic shunts, both before and after artificial portocaval anastomosis, and in two patients with thrombosis v. lienalis, excessive splenomegaly, and extensive portosystemic shunts before and after splenectomy. In six patients (about 55%), a reduction of the effective liver blood flow occurred due to the artificial portosystemic anastomosis; the average decrease was about 20%. In seven patients, a significant enlargement of the total splenosystemic flow was observed as a result of the artificial communication. In both patients, an increase of the effective liver blood flow occurred after splenectomy. The minimal preoperative splenosystemic flow was about 0.152 and about 0.089 of the circulating blood per minute (expressed by means of $k_{Au}$). The significance of the $k_{Au}$ and $k_{RR}$ values as well as that of the ratio $k_{RB}/k_{Au} \cdot 100$ for the estimation of changes in hepatic and portal hemodynamics are discussed. (auth)

**14541** COMPARISON OF $^{113m}$In AND OTHER SHORT-LIVED AGENTS FOR CEREBRAL SCANNING. O'Mara, Robert E.; Subramanian, G.; McAfee, John G.; Burger, Charles L. (State Univ. of New York, Syracuse). J. Nucl. Med.; 10: 18-27(Jan 1969).

Diethylenetriaminepentaacetic acid (DTPA) labeled with $^{113m}$In is a satisfactory short-lived agent for brain-imaging applications. The degree of accuracy in the diagnosis of cerebral lesions in a small clinical series was comparable to $^{99m}$Tc-pertechnetate. $^{113m}$In-DTPA appeared to offer certain advantages over the latter agent including: more rapid clearance from the bloodstream; superior tumor-to-brain concentration ratios in both transplanted ependymoblastomas in mice and in human tumors; absence of visible concentration in the choroid plexus and salivary glands; and more economy for continuous use because of the much longer physical half-life of the parent nuclide $^{113}$Sn. Thus in remote geographical areas one may be relieved of the dependence on weekly shipments of a generator system. These features, however, are offset by certain characteristics which are inferior to those of $^{99m}$Tc: the higher energy of the gamma emission tends to produce somewhat inferior images to $^{99m}$Tc in resolution and, because collimators with thicker septa must be used, the sensitivity of detection of $^{113m}$In is lower for the same activity of $^{99m}$Tc; the fraction of gamma emission undergoing internal conversion is higher than for $^{99m}$Tc, and this contributes to the radiation dose; the radiation dose to the critical organ, the bladder, is higher than for $^{99m}$Tc; the agent is not as satisfactory as $^{99m}$Tc for imaging studies with the Anger camera because of somewhat poorer resolution and fall-off in detector efficiency with the higher gamma energy; and repeat studies cannot be performed in the face of unsatisfactory examinations because of the rapid blood and tissue clearance combined with a relatively short physical half-life. Compared with $^{68}$Ga, the only other radioactive cation available from a generator system, $^{113m}$In appears to be much more superior for imaging applications except for coincidence counting systems. Furthermore, the radiation dose levels are much lower than for equivalent activities of $^{68}$Ga. As a radioactive cation $^{113m}$In may find important applications in the future in various compounds which cannot be labeled with anionic $^{99m}$Tc. (auth)

**14542** KINETICS OF RADIONUCLIDES USED FOR BONE STUDIES. Weber, D. A.; Greenberg, E. J.; Dimich, A.; Kenny, P. J.; Rothschild, E. O.; Myers, W. P. L.; Laughlin, J. S. (Sloan-Kettering Inst. for Cancer Research, New York. Memorial and James Ewing Hospital, New York. Cornell Univ. Medical Coll., New York.). J. Nucl. Med.; 10: 8-17(Jan 1969).

Quantitative comparisons of the kinetics of $^{47}$Ca, $^{18}$F, $^{85}$Sr and $^{87m}$Sr were made in humans. In addition to these nuclides, the uptake of $^{68}$Ga in rat bone has been studied. The results of studies both in patients and in animals indicate that $^{18}$F is the most suitable of the three short-lived nuclides for bone scanning. This is so despite the fact that greater precautions are needed to avoid confusion due to high radioactivity in the urine. Results with $^{68}$Ga show poorer localization characteristics for applications in bone scanning. In contrast to the other nuclides investigated, $^{18}$F has the highest lesion-to-normal bone differential between three and five hr after injection; shows the most rapid plasma clearance and the greatest short-term excretion, giving better scans of the skeleton; gives low radiation dose to the patient while providing good counting-rate statistics; localizes rapidly at bony sites; decays rapidly to permit sequential studies; and decays by positron emission and thus provides unique physical detection characteristics. (auth)

**14543** /sup 113m/In-ETHYLENEDIAMINETETRAACETATE (EDTA) AND RENAL SCINTIGRAPHY. Hoer, G.; Haubold, U. (Univ., Munich). Klin. Wochensch.; 47: 550-1(15 May 1969). (In German).

A method of preparation of a $^{113m}$In-ethylenediaminetetraacetate chelate with $FeCl_3$ and characteristics of its deposition in kidney tissue were described. The particular advantage of $^{113}$In over radioisotopes used previously is its short half life of 109 min. With equal distribution of the $^{113m}$In within the extracellular space, the blood and whole-body doses were from 0.034 to 0.005 rad/mCi. The critical organ was the internal bladder wall, which received a dose of 0.39 rad/mCi, assuming that the bladder weighed 300 g, was globular, and was emptied 1 hr after injection of the labeled chelate. The uptake of the $^{113m}$In-chelate was very rapid, and 40 to 60% was excreted in the urine within 20 min of injection. The chelate seemed to be more suitable for $\gamma$ camera scintigraphy than for conventional renal scintigraphy. It was deposited primarily in the renal pelvis and calices. Dehydration of the patient did not improve the quality of the scans. When both kidneys had normal function, renal scans were inadequate, and scans of adequate quality were obtained only in patients with one functioning kidney. (BBB)

**14544** RELATIVE FUNCTION OF THE HOT AUTONOMOUS THYROID NODULE: DOUBLE AND SINGLE ISOTOPE AUTORADIOGRAPHIC STUDIES. Miller, J. Martin; Block, Melvin A. (Henry Ford Hospital, Detroit). J. Nucl. Med.; 10: 691-6 (Nov 1969).

Double and single isotope autoradiography using $^{125}$I and $^{131}$I, makes possible the demonstration of the activity of thyroid nodules with autonomous function relative to that of normal thyroid. The degree of function per unit volume of these lesions may be greater

or less than nonsuppressed normal follicles, and the key descriptive adjectives should therefore be autonomous and functioning, rather than hyperfunctioning. (auth)

**14545** BRAIN ATROPHY, HYDROCEPHALUS, AND DEMENTIA IN ADULTS. Braham, J.; Front, Dov; Sarova-Pinhas, Ida; Kosary, I. Z.; Czerniak, P. (Government Hospital, Tel-Hashomer, Israel). Israel J. Med. Sci.; 5: 1213-18(Nov-Dec 1969).

Communicating hydrocephalus in adult patients has been associated with progressive dementia and disturbances of gait. Benefit may result from ventriculo-atrial shunt. Of 35 patients with hydrocephalus and dementia, 12 were considered to belong to this group, and the remainder as being cases of degenerative brain atrophy. Differential diagnosis may be made partly on clinical grounds, but more reliably on radioisotope investigation of cerebrospinal fluid hydrodynamics and by pressure studies designed to measure rates of cerebrospinal fluid absorption. Representative case histories, with illustrations of results of these special examinations, are described. In three patients in whom ventriculo-atrial shunt was technically satisfactory, improvement was excellent in one and partial in two. (auth)

**14546** SCINTIGRAPHIC DETERMINATION OF REGIONAL LUNG PERFUSION. Giuntini, C.; Fazio, F.; Santolicandro, A. M.; Navalesi, R. (Univ., Pisa, Italy). J. Nucl. Biol. Med.; 12: 146-51(Oct-Dec 1969).

The technic of radioisotope lung scanning was applied to the quantitative determination of regional pulmonary blood flow. A dose of about 200 $\mu$Ci of $^{131}$I-labeled human serum albumin macroaggregates was injected slowly to each subject during quiet breathing. It was found important to correct the counting rate, as derived from the scanning, for the variability of the frontal and the antero-posterior lung dimensions. The first correction was accomplished by taking the maximum number of scanner markings that happen to fall in any two cm of each line of the scanning. The second correction was obtained by calculating the fraction of the counting volume of the detector that is superimposed to pulmonary tissue at different lung levels. These corrections served the purpose of relating the counting rate to unit of lung volume. The results were expressed either by taking the ratio of the upper third to lower third lung blood flow, or by making use of parameters, such as the mean, the mode, and a measure of the skewness of the entire distribution of blood flow per unit of lung volume. The relative merits of the two ways of expressing the results are discussed. (auth)

**14547** SEQUENTIAL LIVER SCANNING. Johnston, Gerald S.; Jones, Alfred E. (Walter Reed General Hospital, Washington, D. C.). J. Surg. Oncol.; 1: 205-11(1969).

The liver scan is a significant aid to clinical diagnosis. The value of liver scanning is greatly enhanced when abnormal findings are rechecked with additional scanning at intervals determined by the individual situation. Sequential $^{198}$Au liver scans have been particularly useful in evaluating the response to therapy of neoplastic disease metastatic to the liver and of liver abscess. (auth)

**14548** ALTERATIONS IN RADIOACTIVE ISOTOPE RENOGRAM PATTERN WITH URINARY BLADDER FILLING. Harbert, John C.; Fraley, Elwin E.; Deckers, Peter J. (National Cancer Inst., Bethesda, Md.). J. Amer. Med. Ass.; 211: 810-11(2 Feb 1970).

Patients without renal disease were examined with scintillation camera renography with the bladder filled and then emptied. Bladder filling produced a renogram pattern of prolonged transit time that was reproducible with or without catheterization. Patients should be asked to void before radioisotope renography, especially when the patient is given a water load and when more than one study is being performed. (auth)

**14549** ISOTOPE ENCEPHALOGRAPHY WITH CHOLOGRAFIN $^{131}$I. BIOLOGIC AND PHYSICAL CHARACTERISTICS. Fish, Victor J.; Marshall, W. H. Jr.; De Nardo, Gerald L. (Univ. of California, Berkeley). Amer. J. Roentgenol., Radium Ther. Nucl. Med., 106: 724-30(Aug. 1969).

The effective half-life of cholografin (iodipamide)-$^{131}$I varied from patient to patient. In patients with normal liver tests it ranged from 14 to 18 hours. Patients who had abnormal liver function showed an increased effective half-life (E.H.L.) as long as 58 hrs. Blocking the excretory routes by the intravenous injection of 20 cc of nonradioactive cholografin, followed by 20 $\mu$Ci of radioactive cholografin did not change the E.H.L. appreciably, but delayed the peak of concentration in the liver. Liver and renal functions as well as the amount injected determine the excretory pattern. Cholografin-$^{131}$I was found to be a useful agent for brain scanning when compared with chloromerodrin-$^{203}$Hg, R.I.S.A.-$^{131}$I and $^{99m}$Tc. The whole-body irradiation burden compared favorably with chlormerodrin-$^{203}$Hg and R.I.S.A.-$^{131}$I. However, attention is called to the fact that its dose is larger than that delivered by 10 mCi of $^{99m}$Tc. (auth)

**14550** THE 88th ANNUAL SESSION OF THE AMERICAN SURGICAL ASSOCIATION, BOSTON, MASSACHUSETTS, APRIL 17–19, 1968. Ann. Surg.; 168: 311-778(1968). (CONF-680458).

Three separate abstracts were prepared for inclusion in NSA. Other papers concerned surgical problems, cancer, immunity, and the education and training of surgeons. Conference papers were published in Annals of Surgery, Vol. 126, issues 3 and 4. (C.O.)

*For abstracts of individual papers see: 13763, 14409, and 14410.*

**14551** RADIATION EXPOSUR IN ROENTGENOGRAPHY OF THE SPINE. Seyss, R. Med. Monatsschr., 22: 304-5(July (July 1968). (In German).

Dosimetry for roentgenologic procedures concerning the vertebral column is discussed. Because of the relatively high x-ray dose administered to the patient, the responsibility of the radiologist is stressed. (H.B.G.)

**14552** AN OPHTHALMIC ARGON LASER PHOTOCOAGULATION SYSTEM: DESIGN, CONSTRUCTION, AND LABORATORY INVESTIGATIONS. L'Esperance, F. A. Jr. Trans. Amer. Ophthalmol. Soc., 66: 827-904(1968).

A powerful continuous-wave argon ion laser was constructed and adapted for ophthalmic use. Optical delivery systems were devised for the photocoagulation of anterior segment, intraocular, and surface vascular abnormalities. In vitro blood studies and qualitative histopathologic investigations were performed in order to limit the ocular effects of argon radiation. Quantitative threshold damage levels for retinal tissue were determined, and the importance of these studies with reference to future clinical investigations was discussed. (auth)

**14553** COLORED ROENTGEN PICTURES IN THE SERVICE OF THE GONADAL REGION. Boeck, G. Fortschr. Geb. Roentgenstr. Nuklearmed.; 107: 799-802(Dec 1967). (In German).

Use of the intensification due to secondary chromogen effect (Kankelwitz) makes it possible to produce radiographs with reduced radiation dose (reduction in mAs). The saving in radiation is between 50 and 60%. The radiographs are produced in black and white with reduced radiation dose and are subsequently rendered in color; they contain the same information content as normally exposed films. The expense in time and materials is not prohibitive. The method can be recommended particularly for the gonadal areas. (tr-auth)

**14554** COMPARATIVE PYELOGRAPHIC AND NEPHROSCINTIGRAPHIC EXAMINATIONS OF HIGH-PRESSURE PATIENTS. Hundeshagen, H.; Stender, H. St. (Medizinische Hochschule, Hanover). Radiol. Diagn.; 10: 261-8(1969). (In German).

The results of pyelography, renovasography, radionephrography and nephroscintigraphy for 178 high-pressure patients are compared. Pyelography shows pathological results in 31 per cent, scintigraphy in 51 per cent of cases. Scintigraphy with information storage by subtraction analysis additionally represents localized pathological changes of parenchyma which cannot be detected by means of pyelography, angiography and radionephrography. The results of pyelography and scintigraphy agree in about 70 per cent of cases. (auth)

**14555** FATAL PULMONARY EMBOLISM. Poe, Norman D.; Dore, Earl K.; Swanson, Leonard A.; Taplin, George V. (Univ. of California, Los Angeles). J. Nucl. Med.; 10: 28-33(Jan 1969).

In 700 patients with suspected pulmonary embolism, massive embolism was the primary cause of death in seven. Of these seven, all had signs or symptoms of emboli preceding the fatal episode by one week or longer. At autopsy adherent emboli in major vessels or branches were present in six and correlated well with the areas of ischemia in the scan. Because lung scanning can detect ischemia produced by occlusion of vessels greater than a few millimeters in diameter and because adherence of the emboli to the intima indicates presence within the vessel for at least four to five days, the nonlethal embolic episodes could have been detected in time to institute prophylactic anticoagulation. Lung scanning, by early confirmation of developing pulmonary emboli disease, combined with adequate anticoagulation should materially reduce the mortality from this disorder. (auth)

## Radiotherapy

*Refer also to abstracts 14251, 14312, 14314, 14409, 14415, 14485, 14491, 14495, 14496, 14507, 14591, 14608, 14611, 14613, 14614, and 14616–14620.*

**14556** $^{131}$I LYMPHOGRAPHY OR ENDOLYMPHATIC RADIOTHERAPY. Evers, W. T.; Hagen, J. A. C. (Katholieke Univ., Nijmegen, Netherlands). Ned. Tijdschr. Geneesk.; 113: 329-33 (22 Feb 1969). (In Dutch).

The dosimetry of $^{131}$I lymphography was discussed. Estimates of the irradiation dose from $^{131}$I lymphography ranged from 200 to 10,000 R/mCi. As calculated from autoradiographic studies, the dose was estimated to be 870 R/mCi. Estimates of the irradiation dose in the lung ranged up to 50 R/mCi. The results of the use of $^{131}$I lymphography in 13 patients as treatment for lymphoreticular systemic diseases and tumors with lymph node metastases were described. In Hodgkin's disease, endolymphatic radiotherapy produced a more intense localized effect than chemotherapy. The limitations of $^{131}$I lymphography in treatment of these diseases were also discussed. (BBB)

**14557** PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR CANCER RESEARCH, 60th ANNUAL MEETING, MARCH 23–25, 1969, SAN FRANCISCO, CALIFORNIA. Proc. Amer. Ass. Cancer Res., 10: 1-117(Mar. 1969). (CONF-690313-(Abst.)).

Abstracts of 407 papers presented at the 60th annual meeting of the association are presented. Papers within the scope of NSA will appear under separate abstract at the time of their publication in NSA. An author index to the abstracts is included as well as a section containing the minutes of the annual board meeting and reports of the local sections of the association. (E.R.B.)

**14558** PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR CANCER RESEARCH, 59th ANNUAL MEETING, APRIL 11–13, 1968, ATLANTIC CITY, NEW JERSEY. Proc. Amer. Ass. Cancer Res., 9: 1-122(Mar. 1968). (CONF-680451-(Abst.)).

Abstracts of 315 papers presented at the 59th annual meeting of the association are presented. Eight papers fall within the scope of NSA. The titles and authors of these papers are as follows: In Vitro Radioisotope Studies of Mammary Tumor Virus (MTV). R. D. Cardiff, P. B. Blair, and K. B. DeOme. Oxygen Enhancement of Radiation Effects in Normal Skin. K. Chary. Comparison of Effects of Splenectomy and Radiation of Spleen or Bones in Chronic Myelogenous Leukemia (CML). B. D. Clarkson, L. Bowden, A. Strife, and M. Ogawa. Inactivation of the Mouse Leukemia Virus (Gross) With 4,500,000 R Gamma Irradiation. Ludwik Gross, Bernard Roswit, Stanley J. Malsky, Yalande Dreyfuss, and Charles G. Amato. Albumin Catabolism in Multiple Myeloma by the Whole-Body Gamma Spectrometer. Lippincott, S. W., and Korman, S. Effect of Thyroxine on Thymidine-$^{3}$H Uptake in Pituitaries of Radiothyroidectomized Mice. B. Messier. Further Studies on the Characteristics of Spleen Colonies Formed by Murine Virus-Induced Leukemic Cells. G. B. Rossi and C. Friend. Influence of Microbial Flora and X Radiation on Reticular Neoplasms of rfm Mice. H. E. Walburg, Jr. and G. E. Cosgrove. An author index is also included as well as the minutes of the annual meeting of the board, reports of the local sections, and a list of the members of the association. (E.R.B.)

**14559** THE CHOICE OF OPTIMAL METHODS OF IRRADIATION IN INTRATISSULAR, INTRACAVITARY REMOTE, AND COMBINED BEAM THERAPY. Sinitsyn, R. V. Med. Radiol.; 12: No. 12, 60-4(Dec 1969). (In Russian).

The task of choosing conditions for combined methods of irradiation is discussed. Possible combination of the sources, dictated by clinical and surgical tactics are evaluated. A certain number of problems of linear programming are mentioned. The condition is considered optimal when it satisfies the task of linear programming with the most significant value of the integral form. (auth)

**14560** THEORETICAL CONSIDERATIONS IN THE OPTIMISATION OF DOSE DISTRIBUTION IN RADIATION THERAPY. Fischer, James J. (Yale Univ., New Haven). Brit. J. Radiol.; 42: 925-30(Dec 1969).

The development of an optimum radiation treatment regimen requires manipulation of many variables of which one of the most important is the actual spatial distribution of the radiation dose. A mathematical formula has been developed which permits a rational approach to the problem of choosing an optimal dose distribution. Initially, the tumor is described by a cell density function that measures the expected concentration of cells at any point in the tumor-bearing volume. The formalism then generates the appropriate cell density function that would be expected to apply after any particular treatment. From this information, the probability of cure of the tumor and the probability of recurrence in any region can be calculated. It is suggested that a dose distribution that produces a uniform recurrence probability throughout the original tumor volume will frequently be most advantageous. The proper dose distributions to achieve this result have been derived for several sample tumors under the simplifying assumptions that the population is homogeneous and that multi-target type kill statistics apply. The influence of tumor geometry and of basic restrictions in the treatment plan such as a requirement to use parallel opposed field upon this optimal dose distribution is described. (auth)

**14561** THE ROLE OF RADIODIOTHERAPY AND RADIOACTIVE PHOSPHORUS ($^{32}$P). Storaasli, John. J. Amer. Med. Ass., 210: 1077-8; 81(Nov. 10, 1969).

Radiation therapy is almost invariably beneficial as a palliative procedure in patients with osseous metastases from carcinoma of the prostate. The use of supervoltage equipment, especially for localized pain and the prevention of pathologic fractures and neurologic complication is preferable because of the skin-sparing effects and increased relative depth dose of this modality. In some cases, the use of sodium phosphate $^{32}$P with or without concomitant administration of a testosterone also appears to be a useful adjuvant in widespread bone disease. The usual injection is 2 mCi intravenously every 5 to 7 days. This is discontinued when the white count drops below 2000/mm$^3$ or platelet count below 50,000/mm$^3$. Radiation doses are normally 3000 to 2500 rads over a 2 to 3 week period, but if necessary 2000 to 2400 rads in one week, or single exposure doses of 1000 to 1200 rads can be used. (C.O.)

**14562** INTRAOPERATIVE RADIOTHERAPY OF ABDOMINAL TUMORS. 2. INTRAOPERATIVE IRRADIATION TO CARCINOMA OF THE STOMACH. Fukuda, Masashi; Abe, Mitsuyuki (Kyoto Univ.). Nippon Igaku Hoshasen Gakkai Zasshi, 29: 390-9(July 1969). (In Japanese).

Patients with advanced carcinoma of the stomach were given 1800 to 3000 R of $\gamma$ radiation and 4000 R of 18 MeV electrons during exploratory laparotomy. At autopsy, tumor regression was observed in patients given more than 2500 R. It is believed that patients are benefited by intraoperative irradiation with a single dose of 3000 R. Another group of patients with less advanced carcinomas received irradiation during therapeutic surgery; all patients recovered and were without side effects. (NSA of Japan)

**14563** RECENT EXPERIENCES WITH LiF THERMOLUMINESCENCE DOSIMETRY IN THE RADIUM TREATMENT OF CERVICAL CARCINOMAS. Weise, W.; Reichel, G.; Schultze, H.; Morczek, A.; Bernoth, E. (Medizinische Akademie, Magdeburg, Ger.). Gynaecologia; 168: 126-34(1969). (In German).

The use and advantages of LiF thermoluminescence dosimetry for control of irradiation dosage in Ra treatment of cervical carcinomas were studied. Methods for use of LiF dosimeters, and procedures for irradiation-dose evaluation during treatment are described. Tolerance limits of irradiation doses and dose rates for the large intestine, and rectum are discussed. It is estimated that the highest permissible tolerance dose to avoid stenoses, ulcerations, fistulas, and other injuries of the rectum is 5000 R, given in three fractionated doses. The major advantage in the use of LiF thermoluminescence dosimetry, as compared to other dosimetric methods is that it permits the total dose of irradiation received in the area of Ra implantation to be integrated and recorded cumulatively. Other advantages of LiF that are useful are the nondirectional characteristics of the LiF dosimeters, independence of the dosimeters from an electrical voltage supply, independence from physical environmental factors such as moisture, the minimal irradiation energy dependence over a broad energy spectrum, and the ability to provide simultaneous or integrated measurements of irradiation dose under normal anatomical conditions in the patient. (BBB)

**14564** POSSIBILITY OF APPLYING LASERS IN ONCOLOGY. Kavetskii, R. E.; Sidorik, E. P.; Kogut, T. S. (Kiev Research Inst. of Experimental and Clinical Oncology). Neoplasma; 16: 535-42(1969).

The existence of such characteristics of the laser radiation as monochromaticity, the possibility of obtaining a high energy density over a small area, exerting a local necrotic action on the tumor tissue, high selectivity of radiation with respect to pigmented structures, bloodless nature of the intervention, the minimum side effects on the normal tissue surrounding the tumor are substantial advantages of the laser radiation. The antiblastic effect of laser radiation has been discovered in investigations on the cell in tissue cultures, on inoculated tumors of animals, on experimental tumors induced by cancerogenic compounds. The nature of the injury inflicted on the tumors is influenced by a number of characteristics of laser radiation such as wave-length of the laser radiation, pulse duration, the value of the energy flow per unit area, etc. The effect of the laser radiation on biological objects includes thermal, kinetic, electrochemical and other effects. The response of tumors to the effect of the laser radiation is determined by the size of tumor, pigmentation, fluid content and abundance of stromal elements, the depth of tumor localization, elasticity of tissues, peculiarities of tumor vascu-

larization, etc. The antiblastic effect of the radiation of optical quantum generators, emitting in the red and infrared bands, can be enhanced by applying sensitizing dyes and chemotherapeutic drugs. Definite favorable results have been achieved by the action of laser radiation while treating malignant tumors in man—particularly in the instance of melanomas, melanoma metastases in the skin, in that of pigmented and unpigmented basal-cell epitheliomas, squamous-cell cancer of the larynx, metastases of bronchogenic carcinomas, multiform glioblastomas, etc. An increased laser radiation energy level, development of lasers with different wavelengths of radiation, particularly, in the blue-green and ultraviolet bands, the use of fibre-made optical pieces, of sensitizing dyes, in conjunction with chemotherapeutic drugs—all this will contribute to a more effective utilization of the laser radiation in the treatment of malignant tumors. (auth)

**14565** THE HYPERBARIC CHAMBER AND FIRST CLINICAL RESULTS AT THE RADIOLOGICAL CLINIC HEIDELBERG. Kaercher, K. H. (Univ., Heidelberg). Nunt. Radiol.; 34: 185-9(Mar 1968).

The influence of oxygen on the radiosensitivity of tumors is discussed along with preliminary clinical results. The cases selected for treatment were considered resistant to normal radiotherapy. The first group consisted of recurrent cancers, the second group tumors that were considered resistant from the histological pattern, such as hypernephroma, melanoma, sarcoma, and adenocarcinoma. Also reported are experiments on tumor metabolism and growth under hyperbaric conditions. Reports in the literature have indicated an increased tendency to tumor growth and metastasis under hyperbaric conditions, but experimental results with implanted tumors did not confirm this supposition. In fact, metabolism, especially via the glycolytic pathway, was definitely depressed under hyperbaric conditions, but these effects were reversible and did not seem to have any influence on tumor growth. On the other hand, they were found to be of value in following and controlling management of the tumor and the patient under hyperbaric oxygen radiotherapy. Changes of lactic dehydrogenase, lactate, diphosphopyridine nucleotide, and glycogen were used to follow the influence of ionizing radiation under hyperbaric conditions. Measurement of the oxygen tension in the tissues and comparison of the results obtained under atmospheric and hyperbaric conditions showed that anoxic tumors become more radiosensitive under hyperbaric conditions. The $pO_2$ was definitively increased in the hyperbaric chamber in the center of anoxic tumors, and the results of biochemical tests showed that it is possible to assess the influence of hyperbaric oxygen during radiotherapy of radioresistant tumors with the biochemical methods described. (BBB)

### *Blast and Thermal Effects*

*Refer also to abstract 14610.*

**14566** CYTOGENETIC STUDY ON LEUKEMIA IN ATOMIC BOMB SURVIVORS. Uchino, Haruto (Hiroshima Univ.). Nippon Ketsueki Gakkai Zasshi; 43: 818-24(Oct 1968). (In Japanese).

The high incidence of leukemia that developed in atomic bomb survivors is characterized by an increased frequency of the myeloid type of leukemia. Although chromosomal aberrations following irradiation have been observed, the relation between chromosomal aberrations and leukemia development still remains obscure. Hematological and cytogenetic studies on 25 cases of leukemia in atomic bomb survivors and 47 cases in a nonexposed group were carried out, using chromosome analyses of bone marrow cells. In chronic granulocytic leukemia (CGL), abnormal physical and clinical laboratory findings in 11 exposed and 11 nonexposed cases were fewer in the exposed subjects. Chromosome studies showed that all cases in both groups had Philadelphia ($Ph^1$) chromosomes in high frequency, and there was no recognizable difference in the chromosome pattern between the exposed and nonexposed patients. Chromosome studies in 1 exposed and 3 nonexposed cases during blastic crisis in CGL showed an increase in aneuploidy and additional karyotype abnormalities, besides the presence of $Ph^1$. In acute leukemia in 13 exposed and 32 nonexposed subjects, chromosome studies revealed that there was no difference in the abnormal chromosome pattern, although almost half the cases did not show any chromosomal aberrations. So far no characteristic difference between leukemia in exposed and nonexposed subjects was found in cytogenetic studies. It was pointed out, however, that the $Ph^1$ chromosome is present in very high frequency even in CGL diagnosed at a very early stage. (BBB)

**14567** ETIOLOGIC ROLE OF IONIZING RADIATION IN THE DEVELOPMENT OF LEUKEMIA: CLINICAL AND STATISTICAL STUDIES ON LEUKEMIA IN PATIENTS TREATED WITH RADIOIODINE AND IN ATOMIC BOMB SURVIVORS. Hoshino, Takashi (Atomic Bomb Casualty Commission, Hiroshima). Nippon Ketsueki Gakkai Zasshi; 43: 825-34(Oct 1968). (In Japanese).

The possible etiologic role of ionizing radiation in the development of leukemia in patients given therapeutic doses of radioiodine and in atomic bomb survivors of Hiroshima and Nagasaki was examined. In a survey of patients with hyperthyroidism treated with $^{131}I$ throughout Japan, 2 cases of acute leukemia were found on the basis of a total of 18,513 person-years by the end of 1965. A comparison of the observed number of leukemias that developed with the expected number of leukemias, estimated to be 0.4, that occurred fortuitously among these patients during the observation period, whether or not $^{131}I$ had been given, showed no statistical difference between the 2 values due to the small numbers involved, although the former considerably exceeded the latter. However, analysis of all 29 cases of leukemia that developed following $^{131}I$ therapy and 13 cases of thyroid cancer reported in the literature revealed that the ratio of acute to chronic type and the proportion of patients with the aleukemic type were significantly higher in this group than in leukemia in the general public; the latent period from administration of $^{131}I$ to the onset of leukemia was within 5 yr in most cases, with a mean of about 3 yr. These findings are like those in leukemia following x-ray therapy. The estimated mean blood and bone marrow radiation doses from $^{131}I$ given the patients with hyperthyroidism that eventually developed leukemia were 22.5 and 18.0 rad, respectively. The well-confirmed leukemia cases in atomic bomb survivors of Hiroshima and Nagasaki by the end of 1967 numbered 254 cases, including 169 acute and 85 chronic for Hiroshima, and 153 cases, including 125 acute and 28 chronic for Nagasaki. The distribution of the proximally exposed cases by year of onset showed a peak occurrence between 1950 and 1953 in both cities. The average annual incidence rate per $10^5$ population indicated that the incidence of leukemia rose with the increase of radiation dose for estimated doses of more than 20 rad in Hiroshima and 100 rad in Nagasaki. The incidence rate of chronic leukemia exceeded that of acute leukemia among persons exposed to 20 to 100 rad in Hiroshima. The difference in the dose-response relation on incidence rate and type of leukemia between the 2 cities may be partially related to the nature of radiation. The ratio of $\gamma$ rays to neutrons at the same total air dose level was much higher in Nagasaki than in Hiroshima. The blood leukocyte count measured within 3 months from the time of the bombing was significantly lower in persons who eventually developed leukemia than in persons receiving a corresponding dose of radiation but not developing leukemia. The proportion of patients with radiation cataract that eventually developed leukemia was higher than that in persons matched for age, sex, and exposure dose not developing leukemia. This suggests that persons who developed leukemia following irradiation may have had a high somatic cell sensitivity to radiation in both hematopoietic and other tissues, such as thyroid and lens. (BBB)

## Radiation Effects on Animals

*Refer also to abstract 14498.*

**14568** (NYO-2356-36) STUDIES OF THE EFFECTS OF ULTRAVIOLET RADIATION ON CELL STRUCTURE AND BEHAVIOR. Annual Progress Report, January–November 1969. Freed, Jerome J. (Institute for Cancer Research, Philadelphia, Pa.). 8 Dec 1969. Contract AT(30-1)-2356. 14p. Dep. CFSTI.

Two haploid lines of frog cells were found to be chromosomally stable through more than 200 generations in culture. From the more vigorous line chemical mutagens were used to elicit a high yield of clones resistant to BUdR; all of these appeared to lack the enzyme thymidine kinase. The haploid line, which has a single nucleolar organizer, proved useful in studies of nucleolar function. As a result of studies on puromycin resistance, a stable and highly resistant heteroploid line with useful marker chromosomes was derived. Resistance to both puromycin and actinomycin D is associated with restricted incorporation of the drugs. This drug resistant cell line has application in nuclear transfer and ultrastructural studies. Electron microscope studies were conducted on HeLa cells to determine the relationship of cell motility to the cytoplasmic microtubule system. Measurements of the rate of cell spreading after subculture by the trypsin procedure suggested that microtubules were required for extension of the cells on a growth surface. Attempts were made to extirpate the centrioles with an ultraviolet microbeam for studies on the role played by the centrioles in cell motility. (H.L.W.)

**14569** THE INTERPRETATION OF SPLIT-DOSE SURVIVAL DATA; RECOVERY FACTOR AND PRE-DAMAGE REVERSAL FRACTION. Kiefer, J. (Christie Hospital and Holt Radium

Inst., Manchester, Eng.). Int. J. Radiat. Biol.; 16: 297-300 (1969).

Parameters of the survival curves are usually different from organism to organism and differ with experimental conditions of the same test object. The "pre-damage reversal fraction" (PRF) term has been introduced which is independent of these parameters. The relation between the "recovery factor" and the PRF is shown mathematically. The use of the PRF may make quantitative comparisons between different systems and different experimental conditions easier. (UK)

**14570** EFFECT OF OXYGEN ON CELLULAR SURVIVAL AND RECOVERY AFTER RADIATION. Littbrand, Bo; Revesz, Laszlo (Karolinska Institutet Medical School, Stockholm). Brit. J. Radiol.; 42: 914-24(Dec1969).

Chinese hamster cells were exposed to x radiation in argon with an oxygen content either less than 2 ppM, considered anoxic conditions, or 120 or 400 ppM, considered hypoxic conditions. The survival curve after irradiation with exposures of 800, 1,200 and 1,600 R in anoxia was exponential. In comparison, the survival curve of cells irradiated in hypoxia had an increased regression and an increased extrapolation number at zero dose. When treated with exposures of 150, 300 and 450 R in 1200 ppM oxygen, the number of survivors was about 10 per cent larger than when the exposures were delivered in anoxia. A split-dose ratio close to unity was calculated when the survival after a single exposure of 800 or 1,600 R in anoxia was related to the survival after the same doses delivered in two equal fractions with 18-hour intervals When treatment with the same doses was made in the presence of oxygen, the survival ratio was increased to an extent comparable to the increase of the corresponding extrapolation numbers. When $3 \times 300$ R was delivered with three-hour intervals in hypoxia, the survival was increased in relation to the survival after a similar treatment in anoxia, and also in relation to the survival after a single anoxic or hypoxic treatment with the same total dose. The change in the extrapolation number and the extent of recovery was closely related to the change in the oxygen consumption of cells at the particular oxygen concentrations. The relationship between oxygen concentration and change in the survival regression could be described by the formula suggested by Howard-Flanders and Alper (1957). It was concluded that oxygen may play a dual role in regard to radiation survival: on the one hand it sensitizes the cells by enhancing the radiation damage, and on the other hand it protects them by permitting the oxidative metabolism that probably provides the energy required by the repair processes. (auth) (UK)

**14571** STUDIES ON THE IDENTITY AND PROPERTIES OF STEM CELLS OF BLOOD ELEMENTS. Necas, E. (Karlova Univ., Prague). Cesk. Fysiol., 17: 561-70(1968). (In Czech).

The literature on the recovery of stem cells exposed to total or partial irradiation was reviewed. The differentiation of tissues was determined by morphological examination of the cells; the absence of a stable structure of the bone marrow makes it difficult to identify its stem cells. Such stem cells may exist in the blood; some authors consider the lymphocytes as stem cells. Human bone marrow destroyed by radiation may be replaced by the marrow cells from a donor; many experiments were carried out on animals and observations were made on humans. It is assumed that the inactive lymphocytic stem cells are changed, being able to carry out synthesis of DNA and mitosis. The radiosensitivity of the cells during different stages of the differentiation is reviewed. (Review article, 113 references). (TTT)

**14572** RADIATION SURVIVAL IN SYNCHRONOUS AND ASYNCHRONOUS CHINESE HAMSTER CELLS IN VITRO. Sinclair, W. K. (Argonne National Lab., Ill.). pp 39-54 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

Synchronized mammalian cells enable radiation responses to be examined as a function of the position of the cell within its generation cycle. However, synchrony techniques are limited by the random distribution of generation rates in cell populations and, because of the techniques employed, stages such as $G_2$ and mitosis are difficult to examine. Superposing on the mitotic selection technique high-specific-activity tritiated thymidine to inactivate resistant S cells enables the average sensitivity of $G_2$ and mitotic cells to be established. The changes in sensitivity during the cell cycle for Chinese hamster cells are considerable, at least as great as the effect of the presence or absence of oxygen. Cells in $G_2$ and mitosis are the most sensitive, followed by $G_1$, early S, and finally late S cells as the most resistant. With this data the response of an asynchronous population can be estimated and compared with experimental data. Calculation and experiment agree well. The selection + tritiated thymidine technique is still limited in resolution to a one-hour period. Experiments varying the interval between irradiation and selection indicate that there is, very probably, a brief phase more sensitive than the average in the selected mitotic population that should be examined further. Experiments with Janus (fission) neutrons indicate that the changes in response during the cell cycle are smaller than for x rays and the shapes of the survival curves are different. The RBE of these neutrons is shown to vary with both dose level and position in the cell cycle. (auth)

**14573** MEASUREMENTS OF RELATIVE BIOLOGICAL EFFECTIVENESS AND OXYGEN ENHANCEMENT RATIO OF FAST NEUTRONS OF DIFFERENT ENERGIES. Barendsen, G. W.; Broerse, J. J. (Health Research Council TNO, Rijswijk, Netherlands). pp 55-63 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

Impairment of the reproductive capacity of cultured cells of human kidney origin ($T\text{-}1_a$ cells) has been measured by the Puck cloning technique. From the dose-survival curves obtained in these experiments by irradiation of cells in equilibrium with air and nitrogen, respectively, the relative biological effectiveness (RBE) and the oxygen enhancement ratios (OER) were determined for different beams of fast neutrons. Monoenergetic neutrons of 3 and 15 MeV energy, fission spectrum fast neutrons (means energy about 1.5 MeV), neutrons produced by bombarding Be with cyclotron-accelerated 16 MeV deuterons (mean energy about 6 MeV) and neutrons produced by bombarding Be with cyclotron-accelerated 20 MeV $^3$He ions (mean energy about 10 MeV) have been compared with 250 kVp x rays as a standard reference. The RBE for 50% cell survival varies from 4.7 for fission-spectrum fast neutrons to 2.7 for 15 MeV monoenergetic neutrons. The OER is not strongly dependent on the neutron energy for the various beams investigated. For the neutrons with the highest and lowest energies used OER values of $1.6 \pm 0.2$ and $1.5 \pm 0.1$ were measured. An interpretation of these data on the basis of the shapes of the LET spectra is proposed and an approximate verification of this hypothesis is provided from measurements in which secondary particle equilibrium was either provided for or deliberately eliminated. (auth)

## *Invertebrates*

*Refer also to abstracts 14441, 14472, 14522, and 14575.*

**14574** PHOTOREACTIVATION OF U.V. REACTIVATION IN PROTOZOA. Calkins, J.; Griggs, G. (Univ. of Kentucky, Lexington). Photochem. Photobiol.; 10: 445-9(Dec 1969).

The photoreactivation capacity of ultraviolet reactivation of protozoa was tested and it was found that protozoans which can photoreactivate the lethal effects of uv also photoreverse uv reactivation under favorable conditions. The strain of Colpoda deficient in ability to photoreactivate the lethal effects of uv, likewise failed to demonstrate photoreversal of uv reactivation. X-ray doses were in the range 0-100 kRads. uv doses were in the range 0-33.0 ergs/mm$^2 \times 10^{-3}$. Colpoda cucullus and the Mammoth Cave strain were studied. (auth) (UK)

**14575** AN ANALYSIS OF FITNESS COMPONENTS IN THE BRINE SHRIMP, ARTEMIA SALINA, WITH REFERENCE TO GAMMA IRRADIATION AND INBREEDING DEPRESSION. Squire, Richard Douglas. Raleigh, N. C.; North Carolina State Univ. (1969). 129p.

Thesis.

The first series of experiments investigated the effects of acute gamma radiation on outbred Californian Artemia. Freshly matured males and females were irradiated with doses of 0, 0.1, 1, 2, 5, 10, 50, or 100 kR, and individually pair-mated to untreated animals. Significantly reduced life spans resulted in females after 10 to 100 kR, and in males after 50 and 100 kR. It is proposed that adult Artemia are partially dependent upon replacement tissues for survival. Treated females were completely infecund after doses of 10 to 100 kR. Doses of 1 to 5 kR reduced fecundity. This is ascribed to oogonial lethality. Treated males were completely sterile after 50 to 100 kR. Males which received 5 to 10 kR had an initial fertility period lasting 12 days, followed by permanent sterility. A secondary period of fertility followed the sterility period of some 2 kR males. No sterility occurred at lower doses. The second series of experiments investigated the effects of inbreeding and an acute maternal 1 kR dose of gamma radiation of $X_1$ Artemia. Three inbred lines were established by full-sib mating from stock #3 Californian cysts, and an additional three lines from commercially obtained Utah cysts. Rapid and pronounced inbreeding depression occurred in all lines, being manifested by reductions in life span, brood size, cyst hatchability,

number of broods, survival to adulthood, net reproductive rate and intrinsic rate of increase, and by total sterility of some males. Following several generations, the inbred lines and their derived populations were usually inviable. Only one of these lines was sufficiently fit to be used in radiation studies for which they were originally intended. This line was derived from stock #3, and had an estimated inbreeding coefficient of 0.76. Despite pronounced reductions of all of the above parameters except hatchability, a maternal oogonial dose of 1 kR had no significant effect on the reproductive behavior of $X_1$ animals. Possible interpretations of these data were discussed. (Disser. Abstr.)

**14576** RADIO-SENSITIVITY AND WATER CONTENT FOR YELLOW MEALWORM EMBRYOS. Po-Chedley, Donald S. (D'Youville Coll., Buffalo). J. Econ. Entomol.; 62: 1505-6 (Dec 1969).

Ova of the mealworm, Tenebrio molitor, were kept according to age in separate vials and incubated at 25°C. Water-loss determinations were made and effects of x radiation (400 to 8,000 R) on partially dehydrated embryos were investigated. The tabulated results show that the free water content of the fertilized egg decreases with age, and the x-ray lethal dosages increased during the same period. (H.L.W.)

**14577** THE EFFECT OF ULTRAVIOLET RADIATION ON BLEPHARISMA UNDULANS JAPONICUS. Hukui, Tosito (Fukuoka Univ. of Education). Fukuoka Kyoiku Daigaku Kiyo, Dai-3-Bu, Rika-Hen; No. 18, 87-92(Dec 1968).

The experimental conditions in the studies of uv radiation on the reddish individuals in the vegetative cycle of the clone H of Blepharisma undulans japonicus Suzuki, 1954 were given. The culture medium (22°C to 23°C) was made by mixing 1 part of pH 7.0 Sörensen buffer with 9 parts rice straw infusion. Ultraviolet radiation (2537 Å, about 3200 $\mu W/cm^2$, humidity 76%) was given for 10 to 140 seconds at intervals of 10 seconds and each uv radiation was repeated every 24 hours. Observation was made 24 hours later after each uv radiation. The photodesensitization and the photoreactivation were prevented. As the results of this experiment, the ranges of existence for various trophic individuals of this subspecies after uv radiation became evident. Moreover, the retardation of binary division of normal trophic individuals and the appearance of various modified trophic individuals were observed. Concerning the latter individuals, the following points were seen; vesiculation of the cytoplasm, enlargement of the contractile vacuole, decrease in number of the food vacuoles, transformations of the macro- and micronuclei, reduction in speed of motion, and immobilization. At the termination of each uv radiation repeated every 24 hours, cytolysises or cyst formations of various modified trophic individuals were observed. (auth) (NSA of Japan)

**14578** EFFECTS OF X-RADIATION AND THE INSECTICIDE DDT ON MORTALITY AND REPRODUCTION OF FLOUR BEETLES, TRIBOLIUM CONFUSUM AND T. CASTANEUM, WITH A GENETIC INTERPRETATION FOR DDT RESISTANCE. Erdman, Howard E. (Battelle-Northwest, Richland, Wash.). Contract AT(45-1)-1830. Ann. Entomol. Soc. Amer.; 63: 191-7 (Jan 1970).

Confused flour beetles, Tribolium confusum Jacquelin duVal, wild-type strain Chicago Standard, and red flour beetles, (Coleoptera: Tenebrionidae) T. castaneum (Herbst) wild-type strain, Brazil cI, and black body mutant, sooty, were used. Populations and all possible single-pair mating combinations of flour beetles were established on food containing various concentrations of DDT (0 to 80 ppm DDT). Virgin, sexually mature beetles were x-rayed with 0, 1, 2, and 4 kiloroentgens. Parental mortality and productivity (number of $F_1$ adults) were measured. Reproductive ability progressively decreased with increasing x-ray exposure. Mortality of females was greater than that for males. Wild-type interspecies comparisons of productivity showed that Brazil cI was reproductively superior to Chicago standard regardless of x-ray exposure in 0 ppm DDT and comparable at 25 ppm DDT. On greater concentrations of DDT in food, Brazil cI was inferior. Productivity of Chicago standard and sooty was comparable when no DDT was present, whereas in the presence of DDT sooty was superior. Genetic tests indicated correlation between DDT resistance and sooty, that is, the factor (s) for DDT resistance simulated an autosomal recessive. A maternal effect was also indicated. Definitive tests would determine whether the DDT-resistant factor was linked with or the same as the sooty gene. Association between a specific biochemical reaction in the production of black pigment and DDT resistance would be of interest for insect control by poisoning a specific metabolic pathway. (auth)

## Vertebrates

*Refer also to abstracts 14404, 14418–14421, 14423–14426, 14430, 14432–14435, 14438–14440, 14449, 14471, 14475, 14513, 14518–14521, 14523, 14526, and 14528.*

**14579** (RLO-2049-3) X RAYS AND TEMPERATURE: SYNERGISTIC EFFECTS ON MORTALITY AND GROWTH OF SALMON EMBRYOS. Wadley, Gerald W. (Washington Univ., Seattle. Lab. of Radiation Ecology). June 1969. Contract AT(45-1)-2049. 32p. Dep. CFSTI.

Four embryonic stages of chinook embryos were irradiated with graded, acute doses of x rays (15 to 1530 R), in duplicate experiments, one developing at ambient temperature and the other at 2°C above. Elevated temperatures tended to increase the radiosensitivity at all stages, while fish in ambient temperature showed stimulation of growth following low doses. (auth)

**14580** (UR-49-1134) LATE PATHO-PHYSIOLOGIC RESPONSES OF DOGS TO HEAD X-IRRADIATION. Kramer, Melvyn W. (Rochester Univ., N. Y. Dept. of Radiation Biology and Biophysics). 1969. 142p. Dep. CFSTI.
Thesis.

Two and one-half years after head x irradiation (1000 R, 1 MeV, dorsal aspect, midline air exposure, 5, 50, 500 R/min) mongrel and beagle-type dogs were studied for late physiological responses. Temperature regulation studies (0°C, 24 hrs) revealed no significant differences in regulatory ability. The irradiated groups stood out with consistently higher ambient rectal temperatures and greater decremental responses to cold exposure. An increase in thermostatic set point in irradiated groups is proposed. Thyrometabolic responses to cold, as indicated by serum PBI and FT4, revealed a possible lag in thermoregulatory response. Irradiated animals consistently displayed a more intense and longer duration thyroid hormone elevation, consistent with augmented hypothalamic-pituitary-thyroid axis activity. Responses observed indicate irradiated animals to be homeokinetically responding differently to cold but still maintaining thermogenesis. Neurological studies indicated slight deficits in various reflex and sense functions. Opthalomologic disorders were noted frequently in the 50 and 500 R/min groups. Neuropathological studies of two irradiated dog brains proved unrevealing. Electrocardiographic studies indicated alterations in the ventricular electrical systole. T-wave alterations, and SGOT elevation in all irradiated groups similar to those observed after cerebrovascular accident, brain electrical stimulation, and myocardial necrosis were found. Results are consistent with sub-clinical or low grade progressive myocardial necrosis thought to result from a sympathetic-para sympathetic imbalance or hyperactivity. Electroencephalography under surgical pentobarbital anesthesia revealed generally slower, higher voltage activity than that seen in control dogs. Generalized slowing, focal slowing, spike-like activity, and rhythm instability was observed, but more frequently in posterior leads. Intolerance to anesthesia was indicated in higher dose rate groups. Evidence presented indicates experimental animals to be in a subacute or chronic clinical period 2.5 to 3 years after head-irradiation, which may be prodromal to more severe or possibly lethal late effects. Slow progression of neural alteration appears likely, and may eventually lead into frank, late radionecrosis. (auth)

**14581** EFFECT OF SPLENIC X-IRRADIATION ON BONE MARROW FUNCTION: EXPERIMENTAL STUDIES OF A SERUM MITOTIC INHIBITOR IN RABBIT AND IN PATIENTS WITH CHRONIC MYELOCYTIC LEUKAEMIA. Maurice, P. A.; Williner, B.; Gindrat, J. J.; Brand, A. (Hopital Cantonal, Geneva). Brit. J. Haematol.; 17: 543-52(Dec 1969).

The effect of a selective splenic irradiation on bone marrow function was studied in rabbits given a single splenic exposure with 300 R of x rays. Serum collected shortly thereafter decreased mitotic activity in suspensions of normal rabbit bone marrow. This in vitro inhibitory effect was only transiently demonstrable in the serum appearing 2 hours after irradiation and disappearing 3 hours later. Five patients with chronic myelocytic leukemia in relapse receiving splenic radiotherapy in large single doses of 200 to 400 R (surface dose) were studied along these lines. Serum collected 3 hours after x-ray treatment was tested with suspensions of normal bone marrow and was found to decrease erythroblastic mitotic activity significantly below the control values observed with serum collected before irradiation. The magnitude of this in vitro effect was to some extent related to the spleen size and the radiation dose. No differences were observed between bone marrow suspensions incubated with preirradiation leukemic serum and normal control serum. (auth) (UK)

**14582** THE EFFECTS OF WHOLE BODY IRRADIATION ON SERUM COLONY STIMULATING FACTOR AND IN VITRO COLONY-FORMING CELLS IN THE BONE MARROW. Hall, Barbara M. (Royal Melbourne Hospital, Victoria, Australia). Brit. J. Haematol.; 17: 553-62(1969).

Using in vitro cultures of mouse bone marrow cells, levels of colony stimulating factor were assayed in serum from mice following whole-body irradiation. No significant differences from

control levels were noted in the period 1 to 32 days following 50, 150, 250 or 450 Rads. A dose of 250 Rads caused a sharp fall in the level of colony-forming cells in the bone marrow followed by regeneration between 6 and 16 days following irradiation. Six to 8 hours following whole-body irradiation, blood polymorphs and serum colony stimulating factor levels were consistently elevated. Splenectomy did not affect this response. The results suggest that serum colony stimulating factor is unlikely to be the major regulator determining regeneration of in vitro colony-forming cells in the bone marrow following irradiation. (auth) (UK)

**14583** ULTRASTRUCTURE OF THROMBOCYTES DURING PROLONGED EXPOSURE OF THE BODY TO SMALL AMOUNTS OF $^{54}$Mn. Lysogorov, N. V.; Filatov, P. P. (Inst. of Medical Radiology, Moscow). Med. Radiol.; 12: No. 12, 42-6(Dec 1969). (In Russian).

Qualitative and quantitative characteristics of the thrombocyte ultrastructure components during prolonged exposure of the body to small amounts of $^{54}$Mn are given. The experiment was set up on 100 male rats that received $^{54}$Mn in the form of the chlorine salt in solution amounting to 11.5 microcoulomb/kg from automatic drinking bowls for 1 yr. Ultrafine sections were prepared and studied with the IEM-51 electron microscope at an accelerating potential of 80 kV. Long-term exposure to $^{54}$Mn produced disturbances in the ultrastructure of thrombocytes, implicating almost all of its components, including destruction of the alpha-granule content, turgiscence of mitochondria and an increase in the number of thrombocytes with P-vacuoles. (auth)

**14584** STERILIZATION OF LABORATORY ANIMAL DIETS USING GAMMA RADIATION. Ley, F. J. (United Kingdom Atomic Energy Authority, Wantage, Eng.); Bleby, J.; Coates, Marie E.; Paterson, J. S. Lab. Anim.; 3: 221-54(Oct 1969).

Sterilization by gamma radiation has proved to be a suitable method for the treatment of a variety of laboratory animal diets intended for specified-pathogen-free (SPF) and germ-free colonies. Due to the high penetrating power of this radiation the diets can be packed before treatment in a manner which prevents recontamination during transport and storage. The main bulk of diets is used for SPF animals and a radiation dose of 2.5 MRad has proved effective for the control of contaminating organisms. No adverse effects on animals receiving the diets have been noted, observations having been made on growth, reproduction and general health. Irradiated diets formulated according to current laboratory animal practice appear to be nutritionally satisfactory. (auth) (UK)

**14585** RADIATION $LD_{50/5}$ AND ITS RELATION TO SURVIVING INTESTINAL STEM CELLS. Hagemann, R. F.; Sigdestad, C. P.; Lesher, S. (Allegheny General Hospital, Pittsburgh). Int. J. Radiat. Biol.; 16: 291-2(1969).

The critical level of proliferative cell survival below which intestinal death occurs is briefly discussed in the light of the following parameters: The total number of proliferative cells in the intestine of the mouse; A measure ($D_0$) of the radiosensitivity of this cell population; The extrapolation number, n, of the cell population; and The $LD_{50/5}$ of the animal. The total number of proliferative cells and total number of crypts in the intestine of the mouse were found to be $1.8 \times 10^8$ and $1.1 \times 10^6$. Thus, it was expected that $2.5 \times 10^5$ proliferative cells would survive a $LD_{50/5}$ exposure. There would remain $2.3 \times 10^{-1}$ surviving cells per crypt or an average of 1 cell per 4.3 original crypts. Hence an exposure of this magnitude resulted in severe crypt depletion; that 50 per cent of the animals survived attests to the great capacity for recovery exhibited by the intestine. (UK)

**14586** EFFECT OF X-RADIATION ON SALIVARY GLAND GROWTH IN THE RAT. I. EFFECT OF SINGLE DOSES ON POST-NATAL DIFFERENTIATION AND GROWTH OF ACINAR AND DUCT COMPONENTS. van den Brenk, H. A. S.; Sparrow, Nancy; Moore, Valerie (St. Thomas' Hospital, London). Int. J. Radiat. Biol.; 16: 241-66(1969).

The effect of x radiation confined to tissues of the head and neck of female rats, on post-natal growth and development of the major salivary (submandibular and parotid) and external orbital (lachrymal) glands was studied by determining allometric changes in gland weight, and by histometric measurements made in the submandibular gland. Single doses of x rays, 200 to 1600 rads, caused dose-dependent reductions in glandular growth rates similar in magnitude for the three organs: in the submandibular gland this was shown to be primarily related to parallel dose-dependent effects on cell proliferation. Auxetic growth (cell enlargement and hypertrophy) and various specific types of cell differentiation occurring in these tissues during their development were radioresistant, and were shown to be compensatory mechanisms that counteracted effects of irradiation on proliferative growth, considerable restoration of submandibular gland weight with preservation of acinar/duct ratios resulting from auxetic growth on acinar cells. In irradiated submandibular and external orbital glands, acinar cell hypertrophy was associated with nuclear enlargement and hyperchromaticism, that is considered to represent polyploidization. The irradiated parotid showed no such nuclear or cell enlargement and greater atrophy, particularly after lower doses. The definition of sexual dimorphism of the submandibular gland in the rat is discussed. No evidence was obtained that local irradiation caused a masculinization of these tissues. (auth)

**14587** REPAIR OF RADIATION DAMAGE INDUCED IN RAT LIVER BY X-IRRADIATION. Barbason, H. (Univ., Liege). Int. J. Radiat. Biol.; 16: 233-40(1969). (In French).

Whole-body irradiation with 450 R has a deleterious effect on mitosis induced by a subsequent hepatectomy, i.e., mitotic lag, decrease of mitotic index, and production of micronuclei. These effects diminish when the delay between irradiation and hepatectomy is lengthened. If this interval lasts 24 hours, the mitotic lag disappears completely. After a 6-week delay, the mitotic index also returns to normal values. The micronuclei disappear in a triple pattern: there is a fast decrease for intervals up to 48 hours, a slower one for intervals varying between 48 hours and 6 weeks, and a still slower decrease after 6 weeks. The last two kinetics could be explained by cell renewal. During the first 48 hours, the decrease of the damage responsible for the production of micronuclei seems to be due to a recovery mechanism. (auth) (UK)

**14588** EFFECTS OF THYROID TREATMENT BY RADIOACTIVE $^{131}$I ON FATTENING OF FEMALE RABBITS. Cho, Choong Ho; Nam, Tchi Chou; Lee, Kyu Seung (Seoul Municipal Coll. of Agriculture, Choongnam National Univ., Taejon, Korea). J. Nucl. Sci. (Seoul), 9: 35-9(1969). (In Korean).

This study was conducted to determine the effects of thyroid function upon fattening of the female rabbits. Fifty female rabbits weighing a mean of 2 kg were divided into experimental and control groups. The experimental group was injected subcutaneously with 3.0 mCi $^{131}$I at one time. Changes of body weight were observed at an interval of 2 weeks and after the periods of 1, 2, 4, 6, and 8 weeks, the rabbits were sacrificed, and their lean meat yields and lean meat percentages were measured. The results obtained were as follows. Body weight of the experimental group showed a gradual tendency of increase as compared with control group the process of treatment time, significance of $P < 0.05$ after 6 weeks and $P < 0.01$ after 8 weeks. Lean meat yield of the experimental group showed no trend of changes after 1 and 2 weeks, but it revealed increasing significance with $P < 0.05$ after 4 and 6 weeks and with $P < 0.01$ after 8 weeks. Lean meat percentage of the experimental group was changed according to the trends of lean meat yield, and showed increasing significance with $P < 0.05$ after 4 and 6 weeks and with $P < 0.01$ after 8 weeks. (auth)

**14589** THE PROBLEM OF SENSITIVITY CHANGES DUE TO WHOLE-BODY PRE-IRRADIATION. Schreiber, H.; Dennin, R.; Schuett, P. (Institut fuer Strahlenforschung, Luebeck, Ger.). Med. Welt; 6: 318-20(8 Feb 1969). (In German).

A group of 76 mice was x irradiated with whole-body fractionated doses of 550 to 800 R that totaled from 2200 to 7000 R. The mortality rates were evaluated for the periods between irradiation doses. In all, 17 animals survived 8 weeks after the last irradiation treatment. These surviving animals had received from 1600 to 3550 R as total doses. Of these, 8 remained from a group of 47 that had received total doses of 2350 R in 3 fractions of 750, 800, and 800 R. Apart from opacities of the lens, that were observed in more than half of the surviving irradiated animals, no additional irradiation effects were found on autopsy. In $\frac{1}{4}$ of the surviving animals tumors or indication of tumors were found but their frequency was no greater than in unirradiated animals of the same type. Previous studies have shown that a single sieve irradiation with a dose of 750 R increased the tolerance of rats toward a second similar dose of irradiation 6 months later, while open field irradiation with a dose of 750 R had no effect on tolerance toward a second irradiation dose. The $LD_{50}$ reported for whole-body x irradiation of young rats and mice was 2200 and 4700 R, respectively, and for adult rats, guinea pigs, and rabbits x irradiated over $\frac{1}{3}$, $\frac{1}{6}$, and $\frac{1}{29}$, respectively of their body volumes, the $LD_{50}$ doses were reported to be 7500, 7750, and 1700 R, respectively. (BBB)

**14590** EFFECT OF X IRRADIATION ON THE ACTIVE TRANSPORT OF GLUCOSE THROUGH THE INTESTINE OF THE RAT IN VIVO. Ponz, F.; Lluch, M. (Univ. of Navarra, Pamplona, Spain). Rev. Espan. Fisiol., 23: 117-26(June 1967).

The successive absorption technique was used to study the effect of x irradiation of rats (600 R) on the active transport of glucose (2.77 mM) by the intestine in situ, with time (2 to 96 hr). The

radioprotective effect of cysteamine was also tested. The irradiation of the whole body of the rats clearly altered glucose absorption. An initial decrease was noted (2 to 8 hr), followed by an increase (24 hr) and later a second phase of inhibition up to 96 hr. The impairment of glucose absorption was attributed to effects on organs of the abdominal cavity, since it was produced both by irradiation of the whole body and by that of the abdominal region alone. On the other hand, no such impairment was noted when the animals were irradiated with the abdomen protected. Cysteamine (10 mg/100 g, given intraperitoneal injection 10 min before irradiation) exerted a radioprotective action. The effect was seen after whole-body, abdomen, or abdomen-shielded irradiation. (BBB)

**14591** STUDIES ON THE COMBINATION OF DAUNOMYCIN AND X RAYS ON OBERLING–GUERIN–GUERIN TRANSPLANTABLE MYELOMA. Dragoni, Giovanni (Univ., Milan); Gaetani, Marcello; Scarpinato, Biancamaria; Palmia, Claudio. Tumori; 55: 85-94(Mar-Apr 1969). (In Italian).

The effect of daunomycin and x rays in association on the survival time of Long-Evans and Wistar rats with Oberling-Guerin transplantable myeloma was studied. The ascites form of the myeloma was injected subcutaneously ($10^7$ cells) or the solid tumor was transplanted intracutaneously. Irradiation was carried out with 200 KV x rays; daily doses of 300 to 500 R for a total of 1500 to 2000 R. Daunomycin was administered in a daily dose of 5 to 15 mg/Kg for 5 to 8 days. No favorable results were obtained in Wistar rats, whereas in Long-Evans rats the combined treatment proved more effective than either treatment alone. In Long-Evans rats histo-incompatibility phenomena against the tumor may have been a cause of the enhanced effect of combined treatment. Survival time was increased from a control value of 16.8 days to 23.0 days. The experimental results are discussed in relation to the use of this association of a chemical and physical agent in clinical treatment. (BBB)

**14592** COMPARISON OF RADIATION-INDUCED BONE MARROW DEGENERATION IN GERMFREE AND CONVENTIONAL MICE. Heit, H.; Fliedner, T. M.; Fache, I.; Schnell, G. (Univ., Ulm, Ger.). Radiat. Res.; 41: 163-82(Jan 1970).

Twenty-four germfree and sixteen conventional mice of the ND-2 strain were given 700 rads whole-body x irradiation and the pattern of radioinduced bone-marrow damage was studied. The decrease in bone marrow cellularity was similar in both groups. By day four to five after exposure, the bone marrow became nearly aplastic, and consequently the blood cell counts reached very low levels. From data presented, it seems unlikely that the germfree state affects cell proliferation in any of the hemopoietic systems, as was described for the gut epithelium. Possible explanations for the prolonged postirradiation survival time of germfree compared to conventional mice are discussed. (auth)

**14593** PROLIFERATION KINETICS OF MOUSE L-P59 CELLS IRRADIATED WITH ULTRAVIOLET LIGHT: A TIME-LAPSE PHOTOGRAPHIC STUDY. Thompson, L. H.; Humphrey, R. M. (Univ. of Texas, Houston). Radiat. Res.; 41: 183-201(Jan 1970).

The proliferation kinetics of uv-irradiated mouse L-P59 cells were analyzed by constructing cell pedigrees from photographs taken with a time-lapse system. After exposure to 35 ergs/mm$^2$, inactivation occurred primarily after a first mitosis, while after 75 ergs/mm$^2$ 48% of the cells became pyknotic or did not enter mitosis. First-division delay was inversely related to the age of the cells at irradiation, but second-division delay was a direct function of the age of the irradiated parental cells. Hence, pronounced delays occurred in all age groups. With successive divisions, generation times in viable clones approached the values of control cells. During postirradiation generations, cell inactivation was frequently preceded by an abnormal mitosis (i.e., multipolar and/or incomplete cleavage); nondividing and pyknotic cells occurred less often. In terms of cell killing (loss of colony-forming ability), $G_1$ cells were the most sensitive and late S-$G_2$ cells the most resistant, in qualitative agreement with the age dependence of first-division delay. After 75 ergs/mm$^2$, 44% of the nonsurvivors were able to undergo one or more mitoses. It was concluded that the effects of uv irradiation, in comparison with irradiation, show some basic similarities as well as differences. (auth)

**14594** RADIATION HYPERTENSION AND NEPHROSCLEROSIS. Wachholz, Bruce W.; Casarett, George W. (Univ. of Rochester, N. Y.). Radiat. Res.; 41: 39-56(Jan 1970).

Rats given single x-ray doses to the whole body or whole-body with temporarily exteriorized kidneys shielded (300 R or 500 R) or to the temporarily exteriorized kidneys only (300 R, 500 R, or 1000 R), together with their surgical and nonsurgical sham-irradiated control rats, were studied periodically for 17 months or longer postexposure for systolic blood pressure and renal histopathology. Increased systolic blood pressure, above the time-dependent increases in nonirradiated animals, was induced by all doses and modes of irradiation; the increases were dose-dependent and time-dependent, but independent of the mode of irradiation at given dose levels. Progressive arteriolonephrosclerosis, greater in degree at given times than that in nonirradiated animals, was induced by all doses and modes of irradiation in dose-dependent fashion. Nephrosclerosis progressed more rapidly in animals whose kidneys were irradiated, less rapidly in those whose kidneys were shielded during irradiation, and least rapidly in nonirradiated animals. The initiation of blood pressure increase by renal irradiation required little renal damage, and this was apparently limited to subtle degenerative and occlusive changes in fine vasculature, especially cortical arterioles. Much of the progressive nephrosclerotic process developed after the rise of blood pressure, apparently partly as a result of the hypertension. (auth)

**14595** EVIDENCE FOR A TOXIC SUBSTANCE OF BACTERIAL ORIGIN IN THE BLOOD OF IRRADIATED MICE. Wilson, Raphael; Barry, Thomas A.; Bealmear, Patricia M. (Univ. of Notre Dame, Ind.). Radiat. Res.; 41: 89-103(Jan 1970).

Germfree mice were used to investigate the presence, nature, and origin of toxins suspected of circulating in the blood following high doses of whole-body radiation. The serum bound iron (SBI) level, that is depressed by the activity of vasoactive toxic substances, was used as an indicator of a radioinduced toxemia. Germfree and conventional CFW mice under control conditions present an almost identical serum iron pattern between the sexes and between the animal states. However, following exposure to 850 R whole-body x-irradiation, different SBI response patterns were evoked in each group. A hyperferremia in x-ray treated germfree mice was sharply contrasted by the induced hypoferremia of x-ray treated conventional animals. Bacterial endotoxin inoculated intravenously provoked a hypoferremic state in both conventional and germfree nonirradiated animals. It also produced the hypoferremic pattern in x-irradiated germfree mice typical of irradiated conventional mice not receiving endotoxin. More explicit proof for the involvement of these vasoactive substances in radioinduced pathology comes from data on irradiated gnotobiotic animals. Germfree mice monocontaminated with a gram-positive organism presented a postirradiation SBI pattern similar to the germfree mice, whereas germfree animals monocontaminated with a gram-negative organism (an endotoxin producer) responded in a fashion similar to the conventional. The serum of irradiated conventional mice was also capable of producing a reduction in SBI when inoculated into nonirradiated mice. The serum of irradiated germfree mice did not have this effect, indicating the absence of this vasoactive substance. It is concluded that the blood of irradiated conventional mice contains a toxic substance of bacterial origin that may contribute to the radiation syndrome. (auth)

**14596** THE EFFECT OF TEMPERATURE ON THE DOSE RESPONSE OF GAMBUSIA AFFINIS AFFINIS FROM TWO NATURAL POPULATIONS. Blaylock, B. G.; Mitchell, T. J. (Oak Ridge National Lab., Tenn.). Radiat. Res.; 40: 503-11(Dec 1969).

The radiation resistance of the common mosquito fish, Gambusia affinis affinis, from two natural populations was compared by establishing $LD_{50(30)}$ for each population. One population was exposed to chronic environmental radiation of approximately 10 rads/day for over 100 generations, while the other population was exposed only to natural background radiation. The $LD_{50(30)}$ for each population were ascertained at environmental temperatures of 20, 25, or 30°C. A statistical analysis of the data based on a modified form of a logistic dose response model showed no significant difference in radiation response between the two populations. However, as the temperature increased above 20°C, the sensitivity of Gambusia to radiation increased. Differences of only 5°C changed significantly the $LD_{50(30)}$ of each population. (auth)

**14597** INFLUENCES OF A CIRCADIAN RHYTHM AND MITOTIC DELAY FROM TRITIATED THYMIDINE ON CYTOKINETIC STUDIES IN HAMSTER CHEEK POUCH EPITHELIUM. Gibbs, S. Julian; Casarett, George W. (Univ. of Rochester, N. Y.). Radiat. Res.; 40: 588-600(Dec 1969).

Mitotic indices in the basal layer to cheek pouch epithelium of Chinese hamsters show a pronounced circadian rhythm. Radiation from tracer doses of tritiated thymidine of high specific activity caused mitotic delay, or temporary interruption of the flow of cells into mitosis. The wave of labeled mitoses method yielded a transit time across S of 10 hours, while double-labeling experiments indicated a synthesis time of about 5 hours. Flow of cells from synthesis through mitosis, upon which the wave of labeled mitoses method depends, was interrupted by mitotic delay from tritiated thymidine, the circadian rhythm, or both, resulting in an overestimate of the duration of S. Data from the double-labeling experiments were analyzed using a steady-state

model which depends on total asynchrony in the dividing population of cells; it is not strictly applicable in the presence of a circadian rhythm. These results stress the need for simultaneous multiparameter analysis and the use of several experimental approaches in cytokinetic studies of cell renewal systems in vivo. (auth)

**14598** MORPHOLOGICAL CHANGES OF DOG CARDIAC MUSCLE IN ACUTE RADIATION SICKNESS. Bespalova, L. A. (Inst. of Biophysics, Moscow). Arkh. Patol.; 31: No. 4, 70-4 (1969). (In Russian).

Morphological changes of the myocardium of dogs at various periods of acute radiation sickness are described. Investigations were carried out on 18 dogs which had been subjected to a single total x irradiation at a dose of 350 R. During the first experimental days the development of vacuoles and protein dystrophy were noted in the dog heart that were most pronounced by the 7th to 12th experimental days. At the height of acute radiation sickness there was noted a depression of restorative processes in the myocardium. A dystrophic-necrobiotic process was nonspecific in nature and was evidently associated with the development of myocardial hypoxia in conditions of stress reaction, caused by irradiation. (auth)

**14599** WHOLE-BODY GAMMA IRRADIATION OF NEWBORN PIGS: THE $LD_{50/30}$. Case, Marvin T.; Simon, Joseph (Coll. of Veterinary Medicine, Urbana, Ill.). Amer. J. Vet. Res.; 31: 113-15(Jan 1970).

Newborn Yorkshire pigs were exposed to 150, 250, 300, 350, 375, 400, and 450 R of $^{60}Co$ $\gamma$ radiation. The irradiated pigs had diarrhea 2 to 5 days postirradiation. Cutaneous hemorrhages developed 9 to 14 days postirradiation. All hemorrhagic or hematopoietic irradiation deaths occurred 10 to 29 days postirradiation. The $LD_{50/30}$ of newborn pigs exposed to $\gamma$ radiation was determined to be 375 R. (auth)

**14600** CORNEAL INJURY PRODUCED BY CARBON DIOXIDE LASER RADIATION. Leibowitz, Howard M.; Peacock, George R. (Army Medical Research Lab., Fort Knox, Ky.). Arch. Ophthalmol. (Chicago), 81: 713-21(May 1969).

The pathological effects upon the eye of exposure to infrared laser radiation emitted by a carbon dioxide ($CO_2$) laser, was studied. A total of 142 rabbit eyes was irradiated at varying dose levels, and each was observed for a period of two months. Within the limits of the power outputs and exposure times considered, clinically detectable ocular damage was limited to the cornea. Five clinical levels of corneal injury were defined, and the dosage of $CO_2$ laser radiation capable of producing each level of injury was determined. (auth)

**14601** VARIATIONS IN THE RADIOLOGICAL RESPONSE IN MAMMALS AS A FUNCTION OF THE RADIATION CHARACTERISTICS. Legeay, G. (CEN, Fontenay-aux-Roses, France). pp 1-15 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968). (In French).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

Studies were carried out on mammals, in which the biological characteristics of the strains were carefully controlled, using protons with energies ranging from 3 GeV to the Bragg peak, high-energy electrons, and neutrons. By means of monoenergetic fluxes good definition of the linear energy transfers is obtained. Cobalt-60 gamma radiation is used as a reference in all the studies. After demonstrating the importance of describing the physical parameters exactly, the results of an analysis of the secondary radiation produced in 600-MeV and 3-GeV proton cascades are presented. The influence of the biological parameters is stressed. With the development of new techniques, studies should become possible on strains in which the flora is controlled and whose standardized living routine reduces the variations in the biological response. Critical study shows that too little is still known about the tests used and that a comparative study of the various investigations that have been carried out would be very useful to radiobiologists. The use of results obtained under difficult conditions by means of accelerators necessitates collaboration with statisticians who have specialized in this type of problem. (auth)

**14602** ROLE OF ASSOCIATED ABSORPTION EVENTS IN LENTICULAR RADIATION INJURY. Rossi, H. H. (Columbia Univ., New York). Contract AT(30-1)-2740. pp 161-70 of Biophysical Aspects of Radiation Quality. Vienna; International Atomic Energy Agency (1968).

From 2nd Panel on the Biophysical Aspects of Radiation Quality, Vienna, Austria. See STI/PUB-171; CONF-670423.

It has been found possible to study the effects of neutrons on the lens of the eye of the mouse at doses of the order of 1 rad. The radiobiological effectiveness of 0.43 MeV neutrons relative to 14.7 MeV neutrons cannot be accounted for by most of the models commonly employed (such as single or multi-hit or -target mechanisms). This is due to the fact that the frequency (per rad of absorbed dose) of energy deposition beyond any threshold level in any size target cannot be in a sufficiently high ratio if it is assumed that events are statistically independent. An explanation in terms of energy deposition appears to require the assumption that two or more targets are in a definite geometrical relation to each other, i.e., that the targets have structure. Implications of these findings to microdosimetry are discussed. (auth)

**14603** ERYTHROID CELLS RESPONSE OF SPLEEN AND BONE MARROW OF MICE EXPOSED TO LOCAL OR "SPLIT-DOSE" IRRADIATION. Hajdukovic, S.; Petrovic, Lj. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Atomkernenergie, 14: 443-4(Nov-Dec 1969).

The exteriorized spleen and the right tibia of $C_{57}$ Bl mice were exposed to local doses of 1000 R and 2000 R respectively. In parallel experiments mice received 400 R of whole body irradiation followed immediately by local irradiation of spleen and the right tibia with 600 R or 1600 R respectively. The regenerating spleen exhibited an increased number of erythroid cells in the experiments with 1000 R or 2000 R delivered as local irradiation but not in the animals whose spleen received the same total dose delivered as split-dose irradiation. An erythrocytic marrow was observed after local irradiation of the tibia with the same dose, but, in the split dose experiments, the bone marrow of the right tibia (400 + 600 R, 400 + 1600 R) was aplastic up to the end of observation (10 day postradiation). The left control tibia receiving 400 R of whole body irradiation only, demonstrated a lower erythroid cell count than in control animals indicating a radiation abscopal effect due to the local irradiation of the opposite tibia and the spleen. The erythroid response after local irradiation of both organs could not be explained through the erythropoietin-regulating mechanisms, but indicated a self-controlled erythroid cell response during the first postradiation days. (auth)

**14604** THE EFFECTS OF CASEIN ON THE REGENERATION OF BLOOD NEUTROPHILS AND LYMPHOCYTES IN RATS INJECTED WITH A RADIOMIMETIC AGENT (CHLORAMBUCIL) AND DEPLETED OF PROTEIN. A POSSIBLE IMMUNOLOGICAL MECHANISM FOR THE LYMPHOPOIETIC EFFECT OF INGESTED PROTEIN. Aschkenasy, A. (Centre National de la Recherche Scientifique, Orleans-La Source, France). Rev. Fr. Etud. Clin. Biol., 13: 792-9(Oct. 1968). (In French).

After a single intraperitoneal injection of chlorambucil, six rats were fed 18 p. 100 casein for two weeks, followed by a protein-free diet (group I). Six other rats were treated with this diet one week before the injection only (group II). After a weight loss of 40 p. 100, on the average after 78 days of deprivation in group I, and 55 days in group II, all the rats were restored for ten days with a diet of 18 p. 100 casein. The leukopenia caused by the chlorambucil reached its maximum four days after the injection, the fall in lymphocyte level being more marked than that of the neutrophils. There followed a partial spontaneous restoration which was more pronounced in group I than in group II. This was apparently caused by the casein administered in group I between the injection of chlorambucil and the protein-free diet. The final weight of the spleen and lymph nodes was much higher in group I than in group II. The germinal centers of the lymph nodes were larger and more numerous in group I. The role of immune reactions in lymphocyte changes is discussed. (auth)

**14605** LARGE CYTOPLASMIC INCLUSIONS IN CRYPT EPITHELIAL CELLS OF NZCW MICE FOLLOWING WHOLE-BODY X IRRADIATION. Bradley, G. E.; Mukherjee, T. M.; Williams, A. Wynn (Otago Univ., Dunedin, N. Z.). Proc. Univ. Otago Med. Sch., 46: 58-60(Oct. 1968).

A study of the effects of ionizing radiation on the epithelium of mouse small intestine revealed large intracellular inclusions in the crypt epithelium. NZCW mice were exposed to doses of 200 and 1350 R of whole-body $^{60}Co$ irradiation, and were killed at 6, 24, and 72 hr. Samples of jejunal mucosa were examined. Crypt epithelial cells were fixed 6 hr after irradiation and seen electron-microscopically contained membrane-bound spherical inclusions 5 to 12 $\mu$ in dia within which there was a variety of cytoplasmic organelles and nuclear remains, some well preserved, others degenerating and more osmiophilic. Recently formed inclusions were invariably surrounded by two unit membranes. Occasional inclusions contained whole, apparently normal nuclei. Large inclusions often indented the nucleus of the host cell. Similar inclusions were seen in material fixed 24 hr after irradiation; their contents, however, were more degenerate making nuclear material or mitochondria difficult to delineate. At 72 hr irradiation few such inclusions were seen in the crypt epithelial cells which contained instead a preponderance of dense bodies. Mitotic cells in the crypts often contained degenerating inclusions. It is suggested

that the inclusions are phagocytic in origin, i.e., phagosomes rather than cytolysosomes. (BBB)

**14606** EFFECTS OF RADIATION ON DEOXYRIBONUCLEIC ACID OF CHICK EMBRYO. Ide, Hiroyuki (Tokyo Univ.). Annot. Zool. Jap.; 42: 142-52(Sep 1969).

When 4 to 5 day chick embryos were irradiated by x rays, DNA-containing granules appeared in the cytoplasm constituting the neural tube. Changes in the numbers of these granules after irradiation took place in parallel with the changes in the amount of free DNA, which could be extracted with a 0.14M NaCl solution from the nuclei of irradiated embryos. When nuclei prepared from irradiated embryos were incubated at 37°C in a sucrose medium containing ATP, a considerable amount of DNA was released from the nucleus into the medium. The amount of released DNA was nearly proportional to the amount of free DNA produced in the nucleus by x-irradiation. By labelling DNA with $^{3}H$-thymidine, it was confirmed that on x-irradiation, the newly synthesized DNA was very apt to be released from the nucleus. The possible mechanism of the appearance within the cytoplasm of DNA-containing granules on x-irradiation was discussed. (NSA of Japan)

**14607** SCINTIGRAPHY OF RAT KIDNEYS DAMAGED BY ROENTGEN IRRADIATION. Wieland, Cuno; Voskresensky, Igor. Med. Arh., 22: 39-45(May-Aug. 1968). (In Serbo-Croatian).

Kidneys of rats were exposed to 4000 R of various types of penetrating ionizing radiation either in single or fractionated doses. Subsequent scanning showed that the tubules were mainly affected. These conclusions were confirmed histologically. (H.B.G.)

## Man

*Refer also to abstracts 14415, 14417, 14437, 14462, 14509–14512, 14514, 14515, 14525, 14553, 14557, 14558, and 14567.*

**14608** TIME RELATIONSHIPS OF RADIATION-INDUCED CHROMOSOME ABERRATIONS IN HUMAN. Schmid, E.; Bauchinger, M. (Univ., Munich. Institut fuer Biologie, Munich). Mutat. Res.; 8: 599-611(Nov-Dec 1969). (In German).

In lymphocytes of 84 female tumor patients, a qualitative and quantitative chromosome study was done for a time interval of a few hr up to 6 yr after a combined radium–x-ray therapy (culture time 48 hr). Immediately after the irradiation, a mean of 34.9% of all analyzed cells had structural chromosome aberrations (S-cells). The average number of breaks per analyzed cell was 0.825, which was 34 times greater than in 12 unirradiated controls. The number of the S-cells decreased within 3.5 years to 25% of the value at the point immediately after irradiation. In the following 2 yr, a significant decrease could not be observed. Yet a slow decrease could be demonstrated up to 25 yr later in an earlier paper. The time changes after irradiation of each aberration type, the frequency, and distribution of the breakage events are discussed. Comparing these results with those of the earlier paper (culture time 68 hr), the influence of the culture time on the time change of radioinduced chromosome aberrations is analyzed. (auth)

**14609** THE CASE OF DELAYED POST-IRRADIATION ULCERATION CURED BY UNSPECIFIC STIMULATION OF ORGANISM. Dobrek, Zbigniew (Instytutu Onkologii, Gliwicae Poland). Nowotwory; 19: 229-31(Jul-Sep 1969). (In Polish).

The case of a patient with late postirradiation necrosis is presented. To the patient with necrosis in the irradiated area, unsuccessfully treated for 20 years, the zymosan treatment was applied. The necrosis was cured. (auth)

**14610** $^{90}Sr$ AND INFANT MORTALITY. Lindop, P. J.; Potblat, J. (St. Bartholomew's Hospital, London). Nature (London); 224: 1257-60(27 Dec 1969).

A recent claim that $^{90}Sr$ resulting from tests of nuclear weapons has killed 400,000 children in the USA since 1945 is discussed, and it is stated that these findings do not stand up to careful analysis. (auth) (UK)

**14611** THE MENSTRUAL AND GENERATIVE FUNCTION AFTER $^{131}I$ THERAPY FOR THYROTOXICOSIS. Vorozhba, N. V.; Filatova, T. P. (Irkutsk Medical Inst., USSR). Med. Radiol.; 12: No. 12, 20-3(Dec 1969). (In Russian).

As a result of studies carried out in 100 women with thyrotoxicosis subjected to fractional (from 2 to 25G) $^{131}I$ radiotherapy (follow-up from 4 to 12 yrs) it was concluded that such quantities of the isotope do not exert any noticeable negative influence on the menstrual and generative function of women and on the state of six children born after treatment. The above treatment led to normalization of the disturbed menstrual cycle only in 18 out of 41 women, it did not, however, cure primary and secondary sterility in 16 cases. In this connection one should employ radioiodine with great care in young women. (auth)

**14612** RESULTS OF CLINICAL AND LABORATORY INVESTIGATION OF CHILDREN WITH $^{210}Po$ CONTAMINATION IN THEIR BODY. Shantyr, V. I.; Chebotareva, E. D.; Kalnıykov, L. Z.; Tarkhanova, M. V.; Vladimirova, A. F.; Blagodeteleva, V. A.; Braunshtein, M. G.; Kogan, L. A.; Krupchitskaya, K. I. (Inst. of Medical Radiology, Kharkov. Physico-Technological Inst., Kiev). Med. Radiol.; 12: No. 12, 30-7(Dec 1969). (In Russian).

Results are presented of a 46 month-long follow up of 10 children into whose bodies $^{210}Po$ gained access as the result of an accident. The maximal amount of $^{210}Po$ was 113 $\mu$Ci and the minimal was 0.28 $\mu$Ci. Clinical, laboratory, and radiometric analyses indicated that the $^{210}Po$ deposition level exceeded the maximum permissible level by 1 to 200 times in most of the examined cases. The general condition of the children was good, but by the 21st and 46th month, a certain derangement of the proteinogenic function of the liver became noticeable. (auth)

**14613** A FOLLOW-UP STUDY OF THE POSTOPERATIVE TELECOBALT-THERAPY FOR BREAST CANCER. Toyozumi, Fusako (Kurume Univ., Fukuoka). Nippon Igaku Hoshasen Gakkai Zasshi, 29: 365-75(July 1969). (In Japanese).

Results of treatment of 168 breast cancer patients with radical mastectomy and $^{60}Co$ therapy from 1957 to 1966 are summarized. Radiation therapy consisted of one field for the cervical area on the affected side, two fields of tangential radiation over the thoracic area, and one field for the axillary area. A total dose of 4,000 R was administered at a daily rate of 200 R. The patients ranged in age from 20 to 70. The five-year survival rate for all patients was 68%. Mortality in relation to age groups is discussed. The incidence of radioinduced pneumonitis and pulmonary fibrosis was 21%. (NSA of Japan)

**14614** LARGE ARTERY DAMAGE AFTER X RADIATION. Johnson, A. G.; Lane, B.; Harding Rains, A. J.; O'Connell, D.; Ramsay, N. W. (Charing Cross Hospital, London). Brit. J. Radiol.; 42: 937-9(Dec 1969).

A case is reported of bilateral external iliac artery stenosis after external pelvic irradiation. Following surgery for an adenocarcinoma of the uterus that had spread, conventional voltage radiotherapy was given. Seven fields were used at 230 kV, 15 mA, with HVT = 2.3 mm Cu; each field measured 15 × 8 cm. The tumor model dose was 3,950 rads and skin exposure 4,000 rads. Fractions of 400 rads were then given to each field and the overall period of treatment was 30 days. Three factors contributed to the external iliac artery damage namely: Dense periarterial fibrosis probably due to irradiation; direct radiation damage to the large arterial wall that healed by fibrosis, and possible secondary damage from narrowing or occlusion of the vasa vasorum; and acceleration on naturally occurring atherosclerosis. (UK)

**14615** DAMAGING EFFECT OF LASERS ON LIVING TISSUE. Blabla, Jan; John, Jan. Prac. Lek.; 21: 323-7(Sep 1969). (In Czech).

The literature on the effect of lasers on animal tissues, specifically the eye, is reviewed. Various types of lasers (ruby, carbon dioxide, helium-neon, and neodymium) and different wavelengths are discussed, together with the possibility that the adverse effects on the tissue are due to heat. Safety precautions that should be observed in working with lasers include wearing glasses that absorb the radiation and protective clothing as well as the usual ones of thorough training of personnel and careful checking and operation. (27 references) (TTT)

**14616** GRENZ RAYS IN THE TREATMENT OF NEVI FLAMMEI. Szymczykowa, Bogumila; Rubsz-Brzezinska, Jozefa (Academy of Medicine, Zabrese, Poland). Przegl. Dermatol.; 56: 217-24(1969). (In Polish).

The development of late radiation reactions in the treatment of the skin lesions was evaluated in relation to the doses used. The 128 cases studied received local total doses of up to 10,000 R, as single doses of 400 to 500 R by the use of 10 KV x rays. The total doses varied from 4500 to 10,000 R, with most patients receiving 7000 to 9000 R. Fifteen cases receiving total doses of 6000 R or more were examined in detail as to the time of appearance and extent of the late radiation reaction. The significant incidence of persistent skin reactions resulting from irradiation in the patients that received doses of 6000 to 10,000 R indicate that the 6000 R dose should not be exceeded in the treatment of this condition. Teleangiectasia, radiodermatitis, and nonhealing ulcers may result if this dose is exceeded. (BBB)

**14617** CYTOGENETIC AND HEMATOLOGIC CHANGES IN AN INFANT IRRADIATED IN UTERO. Jalbert, P.; Patet, J.; Bachelot, C.; Roget, J.; Mouriquand, Cl.; Bernard, Y. (Faculte de Medecine, Grenoble, France). Ann. Fr. Pediat.; 26: 185-94 (Feb 1969). (In French).

Chromosomes and blood cell levels were examined in a 10-day-old infant born of a mother who inadvertently received a 19,000-R dose of 200-KV x irradiation to the upper part of the body during the sixth month of gestation. For a right breast carcinoma she had received 4000 R to the right supra- and subclavicular region, 4000 R to the axillary region, 3000 R to the internal mammary lymphatic chain, and 8000 to the right breast. The initial finding in the infant showed hyperleukocytosis (15,000 to 30,000 cells/$mm^3$), splenomegaly, lymphoid hyperplasia, and atypical lymphoblasts in bone marrow. These abnormalities slowly disappeared over a 30-day period. A cytogenetic study of peripheral leukocytes at 18 weeks of age showed a much higher incidence of chromosome anomalies than in controls. There were 63.4% cells with anomalies (27% chromosome and 73% chromatid anomalies), aneuploidy 24.3%, and an average of 1.02 anomalies/cell (compared to 0.13 in controls). Anomalies tended to decrease but did not disappear in subsequent examinations. Maternal leukocytes showed extensive chromosomal anomalies also (in 70% of cells, 1.9 anomalies/cell). Tests made 29 months later showed fewer anomalies but still at much higher levels than in controls (anomalies in 39.3% of cells, 0.57/cell). (BBB)

**14618** TREATMENT OF CARCINOMA OF THE BRONCHUS BY INTERSTITIAL IRRADIATION: A STUDY OF 198 PATIENTS. Gibbons, J. R. P.; Baker, R. (Brompton Hospital, London). Thorax; 24: 451-6(Jul 1969).

Use of $^{198}$Au to treat 198 patients suffering from inoperable carcinoma of the bronchus with interstitial irradiation is reported, with data on complications and radiation hazards. Standard size cylinders of Au measuring 2.5 mm in length and 0.8 mm in dia were encased in Pt. These grains were irradiated, the resulting radioisotope of gold emitting $\gamma$ and $\beta$ rays. The thin layer of Pt filtered some of the $\beta$ rays, which avoided necrosis of tissue close to the source. The $^{198}$Au seeds used had an activity of between 3.5 and 5 mCi. A tumor, 2.5 cm in dia, implanted with Au seeds activated to 3.5 mCi received about 18,000 rad. Most patients received doses of between 5000 and 15,000 rad. Higher doses (10,000 to 25,000 rad) are well tolerated although there is a slight risk of esophagitis if the irradiated growth is near that organ. The higher the tumor dose, the greater the benefit to the patient, provided side-effects do not occur. The cases of two patients who showed regression of radiological signs, shrinkage of the tumor, and re-aeration of previously collapsed areas of the lung are described in detail. A 28% 1-yr survival rate and a 20% 2-yr survival rate following $^{198}$Au grain implantation at thoracotomy were obtained. Results from endobronchial implantation show a 21% 1-yr and a 10% 2-yr survival rate. That interstitial irradiation has several advantages when compared with conventional radiotherapy is discussed. A disadvantage of this treatment is the radiation hazard to the staff. (BBB)

**14619** INDIVIDUAL IRRADIATION SENSITIVITY OF BONES. Seyss, R. (Krankenhauses, Neunkirchen, Austria). Radiol. Austr.; 16: 235-9(1966). (In German).

Differences in irradiation sensitivity of metastatic bone tumors were studied in patients x irradiated with doses of up to 6000 R. Following irradiation the patients developed scoliosis with definite indications of irradiation damage of the vertebral bodies. Pathological irradiation fractures of the femur and segmental sclerosis of the head of the femur were also observed. No evidence of irradiation injuries of the bladder or rectum, and no ulcerations were observed. It was concluded that the differences in radiation sensitivity of the bones in the patient studied were based on disturbances in bone metabolism caused by the irradiation treatments. If bone metabolism was already depressed by other factors, then the additional irradiation caused localized bone destruction and disintegration. These effects were most prominent at points of stress, such as the neck of the femur. Indirect effects also might have influenced the irradiation sensitivity of the bones. (BBB)

**14620** APROPOS OF A DIFFICULT DIAGNOSIS AFTER INTENSIVE RADIOTHERAPY OF BREAST CANCER: EXTENSIVE RADIODERMATITIS OR RECURRENT CANCER IN ERYSIPELOID FORM. Privat, Y.; Faye, I.; Bellossi, A.; Ancelle, G. Bull. Soc. Med. Afr. Noire Langue Fr., 13: 237-8(1968). (In French).

Massive irradiation was done on the right breast and the corresponding ganglions for an encephaloid cancer of the breast, then similar irradiation was carried out on the left side for a metastatic ganglion in the left armpit. Later, radiodermatitis developed on the irradiated areas, particularly severe on the right side. The eresypeloïd and sclerodermitiform infiltrations spread far away. The question is whether these are distant stasis phenomena secondary to radiodermatitis or an eresypeloïd form of the cancer's relapse. (auth)

**14621** HEMODYNAMIC CHANGES IN PERSONS EXPOSED TO MICROWAVE RADIATION. Fofanov, P. N. (Military Medical Academy, Leningrad). Kardiologiya, No. 4, 124-6(1969). (In Russian).

The main hemodynamic indices were studied in 30 men 25 to 40 years of age who had been exposed to ultrahigh-frequency electromagnetic radiation for 2 to more than 10 years. They showed a tendency to bradycardia, moderate decrease in the stroke and minute volumes of the heart, and slowing of the rate of blood ejection from the left ventricle. Arterial pressure was more or less normal. A compensatory constriction of the precapillary bed was noted in response to the decrease in cardiac ejection. The arteriole reaction was adequate. There was an increase in the tone of the large arteries. A variety of EKG changes indicated an intensification of vagotonic influences on the heart. Some of the workers exhibited signs of overload of the left ventricle and changes suggestive of fluctuations in the potassium-sodium balance in the myocardium. (JPRS)

## Radiation Effects on Plants

*Refer also to abstracts 14454, 14455, 14459–14461, 14465, 14468–14470, 14473, 14474, 14494, 14569, and 14626.*

**14622** EFFECTS OF UV-LIGHT POST-TREATMENTS ON THE SURVIVAL CHARACTERISTICS OF 21 UV-SENSITIVE MUTANTS OF SACCHAROMYCES CEREVISIAE. Parry, James M.; Parry, Elizabeth M. (University Coll., Swansea, Wales). Mutat. Res.; 8: 545-56(Nov-Dec 1969).

The effects of dark-holding and photoreactivating-light treatment after uv exposure was determined in a range of 21 complementing uv-sensitive mutants of the yeast Saccharomyces cerevisiae. The results indicate that the various strains may be classified into four groups on the basis of the effects of dark holding, and dark holding followed by photoreactivation. The characteristics of these groups are: survival increases during dark holding, dark holding followed by photoreactivation has no further effect; survival increases during dark holding, dark holding followed by photoreactivation produces a further increase in survival; survival decreases during dark holding, dark holding followed by photoreactivation has no further effect; and survival decreases during dark holding, dark holding followed by photoreactivation produces an increase in survival. These characteristics are discussed in the light of current views on excision-repair models. (auth)

**14623** DIFFERENTIAL SENSITIVITIES TO GAMMA RADIATION OF PHYLLOXERA GALL AND NORMAL GRAPE STEM CELLS IN TISSUE CULTURE. Arya, H. C.; Hildebrandt, A. C. (Univ. of Wisconsin, Madison). Can. J. Bot.; 47: 1623-8(Oct 1969).

The differential responses were observed of cells from tissue cultures of normal grape stem (GS6-24) and Phylloxera vastatrix Planch. leaf gall (GP4-21) exposed to gamma radiation of 100 to 500,000 R from cobalt-60. The percentage survival of cells decreased with increased intensity of radiation. The mitochondria, spherosomes, and nucleus were visibly affected by radiation. The percentage survival of gall cells was lower than that of normal cells after exposure to the same radiation intensity. The irradiated cells did not recover regeneration even when exposed to the smallest dose of 100 R, though a certain percentage of cells survived during 28 days of observation. The effectiveness of 2-mercaptoethylamine hydrochloride (MEA), and 2-aminoethylisothiouronium bromide hydrobromide (AET) at $1 \times 10^{-2}$–$1 \times 10^{-8}$ M in protecting the cells against gamma radiation was tested by incorporating them in liquid medium containing actively growing cells of normal and gall types. Observation of cells in microcultures exposed to 1,000 R showed that MEA at $1 \times 10^{-4}$ M and AET at $1 \times 10^{-3}$ M decreased the lethality of radiation to normal grape cells considerably more than to the gall cells. The normal cells treated with $1 \times 10^{-3}$ M AET and exposed to 1000-R radiation also divided. (auth) (Canada)

**14624** OXYGEN EFFECT OF $\pi^-$ MESONS IN VICIA FABA. Raju, M. R.; Amer, N. M.; Gnanapurani, M.; Richman, C. (Univ. of California, Berkeley. Southwest Center for Advanced Studies, Dallas). Radiat. Res.; 41: 135-44(Jan 1970).

The measurement of the oxygen enhancement ratio (OER) for $\pi^-$ mesons is reported. The effect measured was the reduction in the rate of growth of Vicia faba roots. The OER values were 1.35 and 1.5 for roots exposed at room temperature and at 4°C, re-

spectively. Since the experiments described were performed with a dose rate of 30 rads/hr, the value of OER at low temperature is of particular interest. Such a value is relatively independent of dose rate; hence, it may be applicable to more intense beams It should also be noted that the OER at room temperature is approximately 2 for conventional radiation (e.g., $^{60}$Co $\gamma$ rays) at a dose rate of 30 rads/hr. (auth)

**14625** EFFECTS OF IONIZING RADIATION ON THE RIBOSOMAL SYSTEM IN RELATION TO INTRACELLULAR REPAIR OF RADIATION DAMAGE. Romani, Roger J.; Ku, Lily Lim (Univ. of California, Davis). Contract AT(11-1)-34. Radiat. Res.; 41: 217-25(Jan 1970). (UCD-34-P-112-37).

The synthesis of rRNA and ribosomes in pear fruit cells was stimulated by a $\gamma$ radiation dose of 250 Krad; the effect persisted for several days. A 1000-Krad dose resulted in complete cessation of ribosomal synthesis with no subsequent recovery. Neither dose had a marked effect on the relative amounts of monosomes and polysomes as determined by sedimentation analyses. For the cells in question the increment in radiation dose that inhibited ribosomal synthesis also resulted in a transition from reparable to irreparable mitochondrial damage. Implications for the dynamics of intracellular repair are discussed. (auth)

**14626** AGING AND REPAIR IN NEUROSPORA CRASSA STUDIED BY ULTRAVIOLET IRRADIATION. Gampel, Zulema; Toha, Jose C. (Univ. of Chile, Santiago). Radiat. Res.; 40: 525-33(Dec 1969).

The curve of viability, showing two components, the linear decay of $D_{37}$ and the similar radiosensitivity per subunit ($\sigma$/n) of young and old macroconidia to uv irradiation, suggest that Neurospora crassa macroconidia might have repair mechanisms that could facilitate its survival during aging. (auth)

**14627** RADIOSENSITIVITY OF SOME SPECIES OF NICOTIANA GENUS. Palakarceva, Marija. Genet. Selektsiya, 1; No. 2, 109-15(1968). (In Russian).

The effect was studied of $\gamma$ rays from a $^{137}$Cs source on seeds of some species of Nicotiana genus (N. tabacum, N. debney, N. goodspeedii, N. glutinosa, N. undulata) after irradiation with 20 kR, 30 kR and 40 kR. The effect was evaluated by the inhibition of mitotic activity and by the amount and type of chromosomal aberrations of anaphasic cells. Varied radiosensitivity was recorded: N. debney (2n = 48) and N. tabacum (2n = 48) proved the most highly radiosensitive species; N. glutinosa (2n = 24) was the most stable species, N. undulata (2n = 40) occupied an intermediate place. The percentage of aberrations increased with the dose. The results are discussed with respect to the problem of the role of polyploidy in the radiation effect on plants. (Abstr. Bulg. Sci. Lit.)

## Radiation Effects on Microorganisms

*Refer also to abstracts 14416, 14422, 14428, 14429, 14431, 14446–14448, 14450–14453, 14456, 14464, 14467, 14569, 14636, and 14638.*

**14628** DNA SYNTHESIS IN SENSITIVE AND RESISTANT MUTANTS OF ESCHERICHIA COLI B AFTER ULTRAVIOLET IRRADIATION. Smith, Kendric C. (Stanford Univ., Calif.). Mutat. Res.; 8: 481-95(Nov-Dec 1969).

The kinetics of growth (cell division) and DNA synthesis were measured in Escherichia coli strains $B_{s-1}$, thy, B, thy, and B/r, thy after uv irradiation (2537 Å). Using a new protocol for studying DNA-synthesis kinetics it was shown that DNA synthesis was not permanently blocked by uv irradiation in the excision-deficient strain E. coli $B_{s-1}$, thy and that cell division proceeded without delay and at a normal rate in the survivors. In E. coli B/r, thy, DNA synthesis was stopped for various periods of time, increasing with the uv dose up to a maximum of about 0.75 generation time. After low doses of uv, synthesis resumed at a near-normal rate for about 60 min and then changed to a rate proportional to the dose of uv. At higher doses, synthesis resumed at a rate proportional to the dose. Cell division was blocked in E. coli B/r, thy for about 120 min and then resumed at nearly the normal rate. The growth and DNA-synthesis kinetic data for E. coli B, thy were not as easy to interpret (because of ever-changing rates) as those for E. coli $B_{s-1}$, thy, and B/r, thy, but were intermediate between these two extremes, consistent with its intermediate uv-radiosensitivity. All three strains showed a rapid increase in viability after uv irradiation during the first 30 to 60 min of growth in minimal medium as compared to zero-time plating on minimal-medium agar plates. This increase corresponded to a dose-reduction factor of 33% for E. coli $B_{s-1}$, thy and 69% for E. coli B/r, thy. (auth)

**14629** RADIATION SURVIVAL OF BACTERIAL SPORES IN NEUTRAL AND ALKALINE ICE. Upadhyay, J.; Grecz, N. (Illinois Inst. of Tech., Chicago). Can. J. Microbiol.; 15: 1419-25(Dec 1969).

The effect of pH values ranging from 6 to 12 on spores of Clostridium botulinum 33A exposed to 0.6 to 0.9 MRad $^{60}$Co resulted in a complex wavelike pattern of survival that was influenced by pH, temperature, and dose of radiation. Within the experiment pH range three typical survival patterns could be recognized. Pattern A (at −190°C) showed peaks of high survival at pH 7 and 9.5 and troughs of low survival at pH 8 and 10 to 11. Pattern B (at −50°C) showed a single broad peak of high survival at pH 8.5 to 9 and troughs of low survival at pH 7 and 10. Pattern C (at 0°C) showed peaks of high survival at pH 7.5 and 10 troughs of low survival at pH 6, 9, and 11. Between the temperatures showing typical A, B, and C patterns the survival profiles indicated various degrees of transition from A to B and from B to C. These results can be tentatively explained in terms of indirect effects, viz. maximum activity of radicals such as ·OH in the troughs and extinction of ·OH by reaction with $e^-_{aq}$ or H· at the peaks. (auth) (Canada)

**14630** THE EFFECT OF A uvr MUTATION ON RESCUE OF U.V. IRRADIATED LON STRAINS OF ESCHERICHIA COLI. Green, M. H. L.; Donch, J.; Greenberg, J. (Palo Alto Medical Research Foundation, Calif.). Photochem. Photobiol.; 10: 397-405(Dec 1969).

Treatments such as plating at elevated temperature, plating in the presence of pantoyl lactone, plating on minimal medium, plating on complete medium after intense white illumination, or plating on complete medium after holding in buffer, are known to increase survival of uv irradiated Lon strains of Escherichia coli. The effect of these treatments on Hcr Lon$^+$ and Hcr Lon strains was studied. Pantoyl lactone and elevated temperature recovery seem specifically related to the Lon defect. Holding in buffer does not enhance survival in an Hcr strain, and only exerts a small effect in an Hcr Lon strain. White irradiation and minimal medium may greatly enhance recovery of both Hcr and Lon strains. However, an Hcr Lon strain is sensitive to white irradiation itself. (auth) (UK)

**14631** THE EFFECT OF RADIATION ON THE MULTIPLICATION OF TOBACCO MOSAIC VIRUS. Lee, Jeoung Ho; Park, Chang Kyu; Oh, Jeung Haing (Radiation Research Inst. in Agriculture, Seoul). J. Nucl. Sci. (Seoul), 9: No. 1, 1-4(1969). (In Korean).

The effects of $\gamma$ radiation and uracil on the inactivation of tobacco mosaic virus (TMV), were studied. The 50% survival dose of $\gamma$ radiation for TMV was $1.7 \times 10^5$ R and the surviving TMV was negligible over the dose of $1.2 \times 10^6$ R. When tobacco seeds were irradiated with different doses of $\gamma$ rays and leaves therefrom were subjected to TMV inoculation, a different rate of virus multiplication was observed. At the concentration of $30 \times 10^{-4}$ M uracil, synthesis of TMV in tobacco leaves was inhibited by 30%. (auth)

**14632** DISSOCIATION BY $\gamma$ RAYS OF VACCINIA VIRUS FUNCTIONS. Decker, C.; Guir, J.; Kirn, A. (INSERM, Strasbourg). Radiat. Res.; 40: 520-4(Dec 1969).

The dissociation by $\gamma$ rays of different functions of vaccinia virus in KB cells was investigated. Attachment to the host cell was poorly affected by $\gamma$ rays. The rate of inactivation of DNA polymerase activity was twice as low as that of DNA synthesis and twenty-five times as low as that of infectivity. The part of the genome involved in DNA polymerase synthesis seems to be one-third of that of DNA synthesis suggesting that at least two other proteins of similar molecular weight would be implicated in DNA replication. (auth)

**14633** GENERAL INHIBITION OF ESCHERICHIA COLI MACROMOLECULAR SYNTHESIS BY HIGH MULTIPLICITIES OF BACTERIOPHAGE $\phi$X174. Stone, Alan B. (Lister Inst. of Preventive Medicine, London). J. Mol. Biol.; 47: 215-29 (28 Jan 1970).

Infection by $\phi$X174 affects macromolecular synthesis in Escherichia coli by two distinct mechanisms. At low multiplicity, host DNA synthesis stops abruptly 15 min after infection, as the result of a process dependent on protein synthesis, while the formation of RNA and protein continues. At higher multiplicities, all macromolecular synthesis is suppressed; the formation of DNA, RNA, and protein is inhibited by a process not prevented by chloramphenicol. Inhibition becomes more pronounced at increasing multiplicities between 4 and 40. Phages that have received numerous lethal hits with nitrous acid or uv radiation retain their ability to inhibit macromolecular synthesis by the second mechanism, which is distinct from lysis from without. The permeability of the cell is demonstrably increased after in-

fection at high multiplicities. Infection at low multiplicity induces partial immunity to subsequent injury by superinfection at high multiplicity. The immunity appears between 5 and 9 min after the primary infection. It does not develop in chloramphenicol, or if uv killed phage are used, but once it has developed it is unaffected by chloramphenicol. (auth)

## Radiosterilization and Radiopreservation

*Refer also to abstracts 14516, 14578, and 14584.*

**14634** STUDIES ON THE STORAGE OF SWEET POTATOES BY GAMMA IRRADIATION. II. Park, Nou Pung (Radiation Research Inst. in Agriculture, Seoul); Choi, Eon Ho; Kim, Young Mu; Kim, Young Chul. J. Nucl. Sci. (Seoul), 9: No. 1, 41-8(1969).

An experiment was carried out to investigate the optimum dose of $^{60}$Co $\gamma$-irradiation for sprouting inhibition of sweet potatoes. The effects of $\gamma$ irradiation on component content, amylase activity during storage, and spoilage molds were studied. The dose of 50 krad was optimum for sprouting inhibition of sweet potatoes. At a level of 100 krad, color of inner tissues turned darker. In sweet potatoes treated with $\gamma$ radiation reducing sugar and non-reducing sugar increased, while starch and reduced ascorbic acid decreased. Amylase activity was remarkably influenced and raised by $\gamma$ irradiation. The average lethal dose for Mucor mucedo, spoilage mold in sweet potatoes, was 300 krad the same as for Rhizopus nigricans. (auth)

**14635** CODLING MOTH CONTROL BY RELEASE OF RADIATION-STERILIZED MOTHS IN A COMMERCIAL APPLE ORCHARD. Proverbs, M. D.; Newton, J. R.; Logan, D. M. (Canada Dept. of Agriculture, Summerland). J. Econ. Entomol.; 62: 1331-4(Dec. 1969).

Release of radiation-sterilized Laspeyresia pomonella (L.) in a commercial apple orchard in the Okanagan Valley of British Columbia from 1966 to 1968 resulted in 0.003, 0.095, and 0.710% injured fruit at harvest in 1966, 1967, and 1968, respectively. All insecticides for codling moth control were omitted until July 1968, when $^2/_3$ of the orchard was sprayed with azinphosmethyl because of an accidental release of substerile moths. Chemical sprays to control mites and other insect pests were selected and timed so as to do the least possible injury to the codling moth. (auth)

**14636** ON STERILIZATION OF BLOOD FOR CELL CULTURES, USING GAMMA RAYS. Zoletto, R. (Istituto Zooprofilattico Sperimentale delle Venezie, Padua); Montalti, M. G. Mal. Infet. Parassit.; 21: 142-4(Feb 1969). (In Italian).

A simple photographic method is described, to determine the number and size of mycoplasma colonies on agar. Its use in the evaluation of the colony/CFU ratio is discussed. (auth)

**14637** EFFECTS OF GAMMA RADIATION ON THE BIOLOGY AND POPULATION SUPPRESSION OF THE TWO-SPOTTED SPIDER MITE, TETRANYCHUS URTICAE KOCH. Nelson, Richard Douglas. Davis, Calif.; Univ. of California (1968). 114p.

Thesis.

Some biological effects of gamma radiation on the two-spotted mite, Tetranychus urticae Koch were determined. A sterilizing dose of 25 krads was established for both sexes. A sub-sterilizing dose given to a male subsequently mated to a normal female was found to cause sterility in the $F_1$ female progeny. LD50/10 values for adult males and female were established at 90 and 110 krads respectively. Eggs were found to be more radioresistant as they increased in age with doses of 3000 to 3200 rads being lethal to all one- and two-day-old eggs, while most all three- and four-day-old eggs hatched after an exposure to 11,500 rads. Male protonymphs, deutonymphs, and adults were all rendered sterile with 20 krads. Eggs and larvae were killed at this dose. A dose of 100 krads did not appear to cause sperm inactivation in males. Multiple matings were found to be common for males, but occurring in only about 10% of the females. A sterilizing dose for males did not detrimentally alter mating competitiveness or longevity. The control of this species in strawberries was attempted using the sterile male technique. A release of both sexes caused a detrimental effect to the plants from the additional feeding activity. An all male colony was obtained from isolated virgin females. A sufficient number of males could not be reared, sterilized, and released to cause a reduction in the endemic field population. A more efficient method for separating the sexes is needed in order that more sterile males may be released per plant. With an effective method of obtaining more males, for release purposes, the sterile male technique may still prove to be useful for this species. A delayed effect in fruit production from high mite populations was observed. A reduction in yield began to occur about 40 days after the peak mite population of 200 to 250 mites per leaflet. (Disser. Abstr.)

**14638** RADIATION AS A TECHNIQUE IN SOIL BIOLOGY AND BIOCHEMISTRY. McLaren, A. D. (Univ. of California, Berkeley). Contract AT(11-1)-34. Soil Biol. Biochem.; 1: 63-73(1969).

A history of the utilization of ionizing radiation in soil science is presented, beginning with observations on the difference in sensitivities of various genera of soil organisms to radiation sterilization and on residual enzyme activities in sterile soil. As a rule, the larger the microbe, the smaller is the minimum dose required. Generally, microorganisms and enzymes are killed or inactivated as exponential functions of dose of radiation, but the dose requirements depend upon the soil type, soil moisture and genus of organism. Irradiation induces release of small amounts of manganese, ammonium, soluble carbon, organic nitrogen, phosphorus etc., from soil microbes and, to a lesser extent, from humus. The nutrients released can stimulate plant growth in radiation-sterilized soil; no toxicity has been noted following soil irradiation. Cells no longer able to proliferate after irradiation may still be biochemically active, e.g., in respiration and nitrification. Irradiated soil is useful for studies of plant-soil-microbe relations in cases where residues from chemical sterilizing reagents or toxic products from steam sterilization treatment are to be avoided. (auth)

# METALS, CERAMICS, AND OTHER MATERIALS

## Metals and Alloys

*Refer also to abstracts 14130, 14866, and 14868.*

**14639** (BNL-50215) HIGH-TEMPERATURE LIQUID-METAL TECHNOLOGY REVIEW. A Bimonthly Technical Progress Review. Volume 7, Number 5. (Brookhaven National Lab., Upton, N. Y.). Oct 1969. 24p. Dep. CFSTI.

Reviews of topical and progress reports operating under contracts with AEC, NASA, and the Air Force are presented. Reviews are included on thermodynamics, fluid dynamics, heat transfer, materials properties and development, instruments, components, chemistry, systems, fabrication, and safety. (J.R.D.)

**14640** (GEMP-1013) AEC FUELS AND MATERIALS DEVELOPMENT PROGRAM PROGRESS REPORT NO. 79. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs). 30 Jun 1969. Contract AT(40-1)-2847. 409p. Dep. CFSTI.

Progress is summarized in 13 sections. A separate abstract was prepared for each section. (J.R.D.)

*For abstracts of individual sections see: 14644, 14692–14698, 14811, 14867, 14892, 14893, and 14966.*

**14641** AIRCRAFT STRUCTURES AND MATERIALS APPLICATION. National SAMPE Technical Conference, September 9–11, 1969, Seattle, Washington. Volume 1. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969). 575p. (CONF-690933).

Thirty-nine papers presented at the conference are included in Volume 1. A separate abstract was prepared for each of eleven papers. Papers for which no abstracts were prepared are concerned with Mg–Li honeycomb structures, polyimide–Ti sandwich components, corrosion, flammability, uses of Kynol fibers, pressure vessels, Ti production and working, mechanical fasteners, composite structures, and adhesion and bonding. (J.R.D.)

*For abstracts of individual papers see: 14675–14678, 14719, 14720, 14879, 14880, and 14905–14907.*

### Corrosion and Erosion

*Refer also to abstracts 13874, 14124, 14202, 14705, and 14708.*

**14642** (GEAP-13539-11) SODIUM TECHNOLOGY DEVELOPMENT PROGRAM. MASS TRANSFER INVESTIGATIONS IN LIQUID METAL SYSTEMS. Quarterly Progress Report No. 11, September–November 1969. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Dec 1969. Contract AT(04-3)-189. 29p. Dep. CFSTI.

Activities in programs devoted to corrosion testing of reactor materials by sodium are summarized. During the report period candidate materials for use as cladding on oxide fuels were studied. Information is included on behavior of Types 304, 316, and 347 stainless steels in loop sodium at 1300°F. Similar information is included on Incoloy 800. Temperature profiles, loop geometry, and sodium purity controls in effect during the tests represent environments of large fast reactors. (J.R.D.)

**14643** (GEAP-13548) CORROSION AND MASS TRANSPORT OF STAINLESS STEELS IN SODIUM SYSTEMS. Roy, Prodyot; Gebhardt, Maxine F. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Sep 1969. Contract AT(04-3)-189. 29p. Dep. CFSTI.

Mass transport and corrosion of austenitic stainless steels in flowing sodium systems have been the subject of several investigations. Broad correlations between materials behavior and experimental parameters have been observed and all studies are in general agreement. In order to explore the limits of performance at potential hotspot conditions, extended corrosion studies have been conducted at 1300°F involving the effects of alloy compositions and of heat transfer. A more detailed evaluation of the effects of velocity and distance downstream was also made. These studies were conducted in flowing sodium for periods up to 3000 hours with oxygen levels of less than 10 ppM. (J.R.D.)

**14644** (GEMP-1013, pp 97-114) PHYSICOCHEMICAL STUDIES OF CLAD $UO_2$ UNDER ACCIDENT CONDITIONS. White, J. F. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

The mode of failure of Zircaloy tubing with 0.927 cm ID and 0.069 cm wall during dynamic testing in a steam atmosphere has been shown to be consistent with predicted behavior based on previous studies on 1.27 cm ID tubing with 0.076 cm wall. The relationship between effective stress, strain, and heating rate during dynamic testing of type 304 L stainless steel tubing in argon may be expressed as follows: $\ln S_0 = 0.1662 [-10.62 + \ln (Er/T) + (93{,}400 \pm 5500/RT)]$. The apparent stress exponent (n) derived from these tests is 6.02. The test facility for dynamic studies on irradiated tubing has been modified to accommodate smaller diameter tubing, to permit testing in a steam atmosphere, and to produce a uniform hot zone at least 5.1 cm in length. A tentative phase diagram for the Zr-$UO_2$ pseudobinary system had been constructed from the results of isothermal quench tests and thermal arrest measurements. Room temperature ductility of Zircaloy-4 measured by the MAB bend test was found to decrease approximately exponentially with increasing oxygen content. No measurable deflection prior to fracture was observed when the alloy contained more than approximately 10 at. % oxygen. (auth)

**14645** (KFK-1061) THE INFLUENCE OF THE "DOWNSTREAM" EFFECT ON THE RESULTS OF SODIUM CORROSION TESTS AND ITS USEFULNESS FOR REACTOR DESIGN. Borgstedt, H. U.; Frees, G.; Drechsler, G. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Material- und Festkoerperforschung). Sept. 1969. 15p. (In German). Dep. CFSTI (U. S. Sales Only).

The downstream effect in liquid sodium corrosion of stainless steels is normally described as an effect of the saturation of liquid sodium with corrosion products. Using the results of corrosion tests the increase in concentration of iron in sodium passing the hot parts of the systems was calculated. The results are compared with the saturation concentrations of iron in liquid sodium. There is no significant raise of the iron concentration in the high temperature sections of the loops. Therefore, the downstream effect cannot be due to the sodium saturation. The test results are free from any saturation influence and from systematic errors due to such an effect. Therefore, the measured corrosion rates can be used for reactor calculations. The downstream effect may be caused by inconstant conditions in the test sections of the corrosion loops. (auth)

**14646** (ORNL-4400, pp 57-68) CORROSION AND CHEMICAL BEHAVIOR IN REACTOR AND DESALINATION ENVIRONMENTS. (Oak Ridge National Lab., Tenn.).

Progress is reported on: assessment of water technology in boiling- and pressurized-water reactors, water chemistry studies in a small state-of-the-art pressurized-water reactor, preparation of standards for primary coolant systems of water reactors, studies of corrosion of electrodeless plated nickel on aluminum at high heat fluxes, corrosion studies of materials in iodine-absorbing reactor containment spray solutions, studies of corrosion of copper alloys in sodium chloride solutions, and carbon dioxide scale suppression studies. Establishment of the Office of Saline Water Materials Information Center is reported. (M.C.G.)

**14647** (RN-S-516) PREVENTION OF RUST IN THE ID WELD AND HEAT AFFECTED ZONE OF CRES 347 NERVA LINES. NERVA PROGRAM. Fletcher, C. W. (Aerojet-General Corp., Sacramento, Calif. Nuclear Div.). Aug 1969. Contract SNP-1. 21p. Dep. CFSTI.

NERVA stainless-steel lines that transport fluids must satisfy rigid levels of cleanliness. One of the most persistent causes of contamination has been the formation of rust in the welds and heat-affected zones of the lines. A three-phase program was conducted to devise preweld methods of preventing postweld rust on the interior surfaces of weld joints. The results indicated that proper preweld treatment, with optimum backup shielding, will prevent postweld rust in the line interior weld and heat-affected zone. (auth)

**14648** RELATION BETWEEN THE STRUCTURAL CONSTITUTION OF Zy-2 AND ITS CORROSION BEHAVIOR IN WATER VAPOR UNDER PRESSURE AT 400°C. Lelong, P.; Perez, M. (Centre de Recherches Metallurgiques de la ste Trefimetaux GP, Argenteuil, France). Metall, 23: 897-903 (Sept. 1969). (In German).

The corrosion behavior of Zircaloy-2 in water or water vapor at higher temperatures under pressure depended not only on its composition, but also on surface and structural conditions. This was shown on industrial Zircaloy-2, forged and rolled to required dimensions, which was examined after heat treatment at $10^{-5}$ torr. The cooling was first slowly performed (150°C/hr) and then rapidly (100°C/min). The velocity of the cooling determined the subsequent behavior of the alloy. The microscopic examination was made

after electrolytic polishing with a high resolution microscope. The transition temperatures were determined by dilatometric measurements. Ratio and conversion velocity of $\alpha$- and $\beta$-components and their relation to the x-phase were strongly influenced by the rapidity of cooling. After the alloy had remained 14 days in 400°C water vapor it showed weight increase due to the formation of an oxide layer of 2 to 3 $\mu$. A close relation between eutectoid separations and dilatometric expansions was also microscopically visible. Surface undulations were observed that were due to a disequilibrium of the $\alpha$- and $\beta$-phase in the intermediate zone and their reversible interconversion. The thickness of the oxidation layer depended on a gradient of composition towards the center of the grains. The irregularity of this layer indicated unfavorable corrosion behavior which depended mainly on the condition of the last $\alpha \rightarrow \beta$ transition. For these reasons it is assumed that the corrosion behavior is affected not only by the cooling rapidity, but also by other more complex conditions, particularly local deviations of the composition of the mixed crystals from that of the alloy. (F.J.W.)

**14649** MICROPROBE STUDY OF CORROSION EFFECTS OF LIQUID SODIUM ON V–Ti–Cr AND V–Zr–Cr ALLOYS. Borgstedt, H. U.; Kegel, B. (Kernforschungszentrum, Karlsruhe, Ger.). Corros. Sci.; 10: 51-4(Jan 1970). (In German).

Corrosion of V–Ti–Cr and V–Zr–Cr alloys at 500 to 600°C by liquid Na containing <10 ppM $Na_2O$ causes the formation of thin oxide layers. Microprobe analysis shows that the layers are enriched in Cr compared to the composition of the alloys and the surface of the metal phase also contains higher amounts of Cr than the uncorroded parts of the materials. Therefore, V appears to suffer preferable oxidation by the $Na_2O$ and vanadium oxide is dissolved by the flowing Na to a higher degree than chromium oxide. (auth) (UK)

**14650** INVESTIGATIONS ON INTERNALLY OXIDIZED SILVER ALLOYS WITH SMALL CONCENTRATIONS OF RARE EARTH METALS. Elssner, Gerhard; Gebhardt, Erich (Max-Planck-Institut fuer Metallforschung, Stuttgart). Z. Metallk.; 60: 922-9(Dec 1969). (In German).

The internal oxidation of silver alloys with small concentrations of dissolved Ho is found to be a diffusion controlled process obeying a parabolic rate law. The effects of time, oxygen pressure concentration and temperature on the subscale growth were investigated. The experimentally measured kinetics are nearly in agreement with the equation of Wagner for the constant of internal oxidation $k_i$. It is assumed that differences between measured and theoretically calculated values are due to the stoichiometric factor v. The deviation from theory seems to result from the temperature dependence of v. Internal oxidation zones are also formed in dilute Ag alloys with small contents of Y, Ga and Er. In oxygen treated dilute Ag–La and Ag–Ce alloys no subscales were detected. Only near the melting-point did internally oxidized and cold deformed samples of Ag–Ho, Ag–Er and Ag–Y alloys show a sharp decrease in hardness by annealing in air. By isothermal annealing in hydrogen internally oxidized and deformed samples were softened even at relatively low temperatures and short annealing times and a coarsening of the oxide particles was observed. On the other hand, samples similarly annealed in air exhibited no decrease in hardness. The stability of the oxide dispersion seems to be a function of the amount of solute metal atoms remaining in the matrix which in turn is controlled by the solubility product of the precipitated oxide and by the concentration of dissolved oxygen. (auth)

**14651** CORROSION OF ALUMINUM AS A REACTOR MATERIAL. Kojima, Kazutaka; Yoshimura, Chozo (Kinki Univ., Osaka). Kinki Aruminyumu Hyomenshori Kenkyukai Kaishi; No. 24, 3-7(Aug 1969). (In Japanese).

In the Kinki University reactor, corrosion of aluminum 2S cladding for fuel elements occurred, and the moderator was contaminated with released fission products. Experiments were made on the corrosion of aluminum 2S in pure water and aqueous solutions of phosphoric acid and hydrofluoric acid. The change in corrosion of the aluminum 2S with time, under reactor radiation, was measured by weighing samples; the increased rate of corrosion, the formation rate of phosphoric acid film, and the change in pH of the water were also observed. Corrosion of the aluminum 2S in the distilled water appeared 200 hrs after the immersion. A hydroxide film and, afterwards, bayerite formed on the sample surface, and the increased rate of corrosion became constant. The pH of water became acidic because of the dissolution of aluminum. In aqueous solutions of 5 ppM phosphoric acid, the corrosion appeared 500 hr after the immersion. The increased rate of corrosion was about twice as much as in the distilled water. A white floating substance formed on the surface of water; in analysis, $Al^{3+}$ and $PO_4^{3-}$ were detected. With increased concentration, the formation of aluminum phosphate increased, while the appearance of corrosion was retarded. In aqueous solution of less than 10 ppM of hydrofluoric acid, the aluminum was not dissolved. A fluoride film formed on the sample surface, and no corrosion appeared 2000 hr after the immersion. (NSA of Japan)

**14652** METAL BODIES HAVING AN OXIDATION-PREVENTING COATING FORMED THERON. (to Siemens Aktiengesellschaft). British Patent 1,181,104. 11 Feb 1970. Priority date 30 Mar 1966, Germany.

Preparation of metals such as Mo, W, Ta, and V incorporating an oxidation-preventing coating is described. The inner coating is primarily a silicide of the metal on which it is deposited. An outer coating is deposited on the intermediate layer consisting of high-melting enamel made of low-silicate glass. (J.R.D.)

**14653** THERMOGRAVIMETRIC STUDY OF ZIRCONIUM OXIDATION UNDER LOW OXYGEN PRESSURE. Dechamps, Michel; Lehr, Pierre (CNRS, Vitry-sur-Seine, France). Compt. Rend., Ser. C; 270: 169-72(12 Jan 1970). (In French).

The zircorium oxidation under low oxygen pressure was studied by means of a thermobalance. The mass increases first as a linear function and then as a parabolic function of time. (auth) (France)

**14654** OXIDATION OF THE URANIUM–ALUMINUM INTERMETALLIC COMPOUND $UAl_3$ IN CARBON DIOXIDE. Pearce, R. J. (Central Electricity Generating Board, Berkeley, Eng.). J. Nucl. Mater.; 34: 151-9(Feb 1970).

Oxidation of the uranium-aluminium intermetallic compound, $UAl_3$, by carbon dioxide in the temperature range 350 to 600°C was studied. The kinetic data indicated that the reaction initially followed a parabolic rate law but later changed to a linear rate law. Activation energies of 47 and 19 kcal/mole respectively for the two stages were obtained. It was shown that the oxidation product was a two-phase mixture, probably of $UO_2$ and alumina. The operative mechanism during oxidation appears to be diffusion of oxygen through a layer of uranium dioxide modified by the inclusion of $Al^{+++}$ ions. The transition from parabolic to linear kinetics is thought to be associated with cracking of the oxide layer. (auth)

**14655** EVALUATION OF VANADIUM AND VANADIUM-BASE ALLOYS IN HOT-TRAPPED SODIUM. Litton, F. B.; Bender, J. H.; Geoffrion, L. A. (Los Alamos Scientific Lab., N. Mex.). Met. Trans.; 1: 441-5(Feb 1970).

Corrosion tests were conducted with vanadium-base alloys in zirconium-purified sodium from 450 to 750°C for 500 to 4000 hr. The materials tested were vanadium, binary vanadium alloys containing from 10 to 40 wt % Ti, and two ternary alloys: V-5Ti-15Cr and V-15Ti-7.5Cr. The sodium was analyzed to contain from 1.7 to 8.7 ppM O by the vacuum-distillation technique. The behavior of these materials was determined from weight change data, and from chemical, metallographic, and electron-microprobe analyses of the test specimens. At temperatures up to 650°C, the maximum weight-change varied from a weight loss of 0.45 for vanadium to a weight gain of 0.46 mg per sq dm-day for the V-40Ti alloy. Chemical analyses of the corrosion test specimens indicated that vanadium-base materials were sensitive to the activity of oxygen, carbon, and/or nitrogen in sodium. Alloys containing >10 wt pct Ti increased in oxygen, carbon, and in some tests, nitrogen content, indicating that alloys of this titanium content are not compatible with sodium of the present purity. Complex titanium carbide precipitates were observed near the surface. V-5Ti-15Cr alloy was more resistant to liquid sodium than the other vanadium materials investigated. (auth)

**14656** URANIUM OXIDES FORMED IN AIR AND WATER IN THE TEMPERATURE RANGE 200 TO 375°C. Orman, S.; Picton, G.; Ruckman, J. C. (Atomic Weapons Research Establishment, Aldermaston, Eng.). Oxidation Metals; 1: 199-207(Winter 1969).

The oxidation of uranium in oxygen, air, and water vapor was studied at 200 to 375°C. Uranium dioxide is the only product found at the uranium-oxide interface and no epitaxy was observed. With increasing thickness of film, oxygen-rich oxides are formed, the composition of the spalled layers being temperature-dependent. The oxide of composition $U_3O_8$ was observed only in the spalled layers at temperatures above 275°C. (auth)

## *Preparation and Fabrication*

*Refer also to abstracts 14016, 14204, 14206, 14693, 14724, 14873, and 14880.*

**14657** (BM-RI-7347) SELECTION OF ANODE MATERIALS AND OPERATING CONDITIONS FOR ELECTROWINNING BERYLLIUM. O'Keefe, D. A.; Couch, D. E. (Bureau of Mines, Boulder City, Nev. Boulder City Metallurgy Research Lab.). Feb 1970. 11p.

The electrowinning of beryllium from beryllium oxide (BeO) using a molten-salt electrolyte composed of 56 LiF-37 $BeF_2$-7 BeO (mole-percent) was investigated. Anodes made of porous carbon were found to be superior in current-carrying capacity and gave a lower cell voltage than other types of anode material tested. When porous carbon anodes were used, the resultant increase in anode area prevented anode passivation. The cell voltage was 3.3 volts, and electrode current efficiencies of 50 to 70 percent were obtained. The electrodeposited beryllium was recovered as beryllium powder or was coalesced to metal beads by heating to 1,300°C. (auth)

**14658** (CEA-Bib-149) FAST NUCLEAR REACTOR FUELS (PREPARATION, FABRICATION, AND PHYSICAL AND CHEMICAL PROPERTIES). Tostain, Jacqueline (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec 1969. 146p. (In French). Dep. CFSTI (U. S. Sales Only).

This bibliography deals with papers published from 1958 to 1968, inclusive, on the fuels for fast neutron reactors (preparation, fabrication, and physical and chemical properties). The abstracts of the papers (except for the monthly and quarterly progress reports and the reviews: "Reactor Materials" and "Transactions of the American Nuclear Society") are included. (510 references.) (auth)

**14659** (CEA-R-3939) VANADIUM PURIFICATION BY TRANSFORMATION TO THE TETRACHLORIDE AND REDUCTION BY HYDROGEN. STUDY OF THE REDUCTION MECHANISM. Val, Christian (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Jan 1970. 134p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Univ. of Paris, Orsay, France.

The problem studied here was the production of very high purity metallic vanadium. The method employed here involved preparing the tetrachloride from the impure metal, purifying it by distillation, an easy process, and finally reducing this tetrachloride with hydrogen to obtain the pure metal. By this technique it was possible to reduce the impurity content from about 5000 ppM to under 500 ppM and, in particular, to eliminate almost completely the nitrogen which is not removed by the normal purification methods. The changes in the morphology of the deposit obtained as a function of the operational conditions were studied. In particular the conditions leading to the formation of a compact deposit were determined. The deposition kinetics are very probably governed by an adsorbed phase reaction at the metal surface. (auth)

**14660** (CEND-3742-356) VANADIUM PURIFICATION. Final Report. La Vake, J. C. (Combustion Engineering, Inc., Windsor, Conn. Nuclear Power Dept.); Wang, C. T. (Wah Chang Albany Corp., Albany, Oreg.). Nov 1969. Contract AT(30-1)-3742. 129p. Dep. CFSTI.

The development of a commercially adaptable process to produce high purity vanadium is discussed. A V-15Cr-5Ti alloy was melted, fabricated into sheet, and the mechanical properties evaluated. Several ingots with a total interstitial content of <400 ppM were melted. Starting material, in all cases, was $V_2O_5$ which was aluminothermically reduced and subsequently electron beam melted to desired purity. Alloying was performed by vacuum and inert gas arc melting composite electrodes of vanadium, chromium and titanium chips. Alloy sheet, 0.040-inch thick, was produced by upset or side forging followed by hot and warm rolling. Tensile and stress-rupture tests performed on the sheet showed that the V-15Cr-5Ti alloy exhibits good strength characteristics without the added strengthening of a high interstitial content. Weld studies show that the alloy is susceptible to embrittlement as a result of TIG welding, due to coring. Electron beam welding showed weld properties similar to parent metal properties when tensile and stress-rupture tested. (auth)

**14661** (ORNL-4313-2) FABRICATION HISTORY OF THE THIRD AND FOURTH ASTM A-533 STEEL PLATES OF THE HEAVY STEEL TECHNOLOGY PROGRAM. Childress, C. E. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 112p. Dep. CFSTI.

The fabrication history of the first two steel plates (HSST plates 01 and 02) for evaluation by the Heavy Section Steel Technology Program was presented in ORNL-4313. Two additional 12-in.-thick A-533 grade B steel plates have been purchased from Lukens for evaluation. They were received for heat treatment in the as-rolled, stress relieved, and descaled condition. These would have been plates 03 and 04, but rerolling of plate 04 caused a change in the numbering system. It was originally planned to leave the plates at 12-in. gage and heat treat them in the same manner as plates 01 and 02 (normalize, austenitize, quench vertically, temper to class 1 mechanical properties, cut into plate sections, and stress relieve). However, it was decided to reroll portions of one plate to 8-in. and 4-in. gage and heat treat portions of the material to class 2 properties. Since plates 01 and 02 were vertically quenched, it was decided to horizontally quench the second pair to test the effects of the quenching procedure. Accordingly, Lukens, who uses a horizontal quenching procedure, was chosen. All material was ultrasonically inspected before and after heat treatment in accordance with PVRC specifications. An objective account of the history of the latest HSST plates is presented. In some instances Lukens' interpretation of the data is given. Otherwise interpretation of the data is not included. (auth)

**14662** (RN-S-515) EVALUATION OF CONSUMABLE WELD INSERTS FOR NERVA LINE WELDS. NERVA PROGRAM. Fletcher, C. W. (Aerojet-General Corp., Sacramento, Calif. Nuclear Div.). Jun 1969. Contract SNP-1. 13p. Dep. CFSTI.

Three types of consumable weld inserts were evaluated. Two types exhibited the best weldability characteristics and minimum weld shrinkage for the tube wall thickness (0.120 in.) utilized in the program. Complete fusion of the insert and uniformity of underbead contour were difficult to achieve with the third type. A mixture of 85% argon–15% hydrogen as the torch shielding gas, in combination with optimum ID weld backup shielding, consistently produced the smooth, contoured, low-crown underbead desired. (auth)

**14663** (RN-S-519) WELDABILITY EVALUATION OF THICK SECTIONS OF HASTELLOY X WITH VARYING ALUMINUM CONTENT. NERVA PROGRAM. Fletcher, C. W. (Aerojet-General Corp., Sacramento, Calif. Nuclear Div.). Jul 1969. Contract SNP-1. 10p. Dep. CFSTI.

Hot cracking and poor wetability of the molten weld metal presented problems in welding the thick sections of the Hastelloy X Phoebus 2 nozzle. A program was conducted to evaluate the effect of varying percentages of aluminum on the weldability of Hastelloy X. The results indicate that lowering the aluminum content of Hastelloy X improves weldability. Utilization of the low-aluminum Hastelloy X material for the NERVA nozzle should result in improved weld quality and lower welding costs. (auth)

**14664** (UCRL-50744) A FUNDAMENTAL STUDY OF THE PRESSURE WELDING OF DISSIMILAR METALS THROUGH OXIDE LAYERS. Ludemann, Wesley D. (California Univ., Livermore. Lawrence Radiation Lab.). Oct 1969. 311p. Dep. CFSTI.

Thesis.

Pressure welding is a solid state welding technique where the weld is made by applying heat and pressure to the metals being joined. The pressure is high enough to mate the weld surfaces, but the metals are constrained so that no general deformation occurs. Elevated temperatures improve welding by increasing the ductility of the metals and by allowing dispersion of interfacial contamination by diffusion or reaction. Metal combinations welded in this investigation include iron-copper, iron-aluminum, beryllium-aluminum, and beryllium-copper. Welds were made with sanded surfaces and with oxidized surfaces. Aluminum, copper, and iron were oxidized by heating the metals in air until about 800 Å of oxide was formed. Beryllium was dipped in a passivating bath to produce a protective layer about 100 Å thick. The thin oxide films residual on sanded surfaces were usually dissipated during welding, and, where metals did not react to form brittle phases, welds were made which exceeded the strength of the weaker metal of the pair. Strong welds were also made at temperatures too low to disperse residual oxides, but the welds were not as strong as the metals. Welds made between metals which reacted to form brittle phases failed either within the brittle phase or at a plane of voids caused by unequal diffusion of the two metals. Strong welds were made through thick layers of interfacial oxides which were not dispersed during welding. The strength of the welds was limited by the strengths of the oxide layers, or by the amount or strength of bonding between the oxides and one of the metals. When oxidized aluminum was welded to beryllium or iron, the hard oxide on the aluminum fractured as the aluminum deformed and bridged across asperities on the iron and beryllium surfaces. This bridging prevented the development of intimate contact so that not much area bonded and welds were weak. When aluminum was welded to anodized beryllium, the hard oxide was on the surface which did not deform. Hence, no oxide bridging occurred and welds were strong, although not as strong as those between sanded surfaces. Good contact occurred when a soft oxide was on the harder metal, as when oxidized iron was welded to

aluminum or copper. However, the iron oxide was weak and weld strength was low. When oxidized copper was welded to iron, the soft oxide on the copper deformed and made good contact with the iron surface, and was reduced to copper with consequent formation of FeO and $Fe_3O_4$. This mixed layer adhered well to both surfaces. It also filled surface irregularities and acted as an adhesive, improving low-temperature weld strength. The strength of this layer limited the strength of the weld to about 10 ksi. Under welding conditions where reaction occurred between sanded metals, the presence of interfacial oxides generally improved weld strength. When iron was welded to aluminum, a layer of iron oxide reduced aluminum diffusion relative to iron diffusion and prevented void formation. The composition of the reaction zone was also changed, and although the welds still broke in the intermediate phase, they were stronger than those made with sanded iron. Welds between sanded beryllium and copper failed at the original interface where voids had formed, but a protective coating on the beryllium reduced diffusion of beryllium relative to that of copper so that no voids formed and the welds were stronger. (auth)

**14665** (WARD-4135-2) STAINLESS STEEL CLADDING DEVELOPMENT. Quarterly Progress Report for Period Ending September 30, 1969. (Westinghouse Electric Corp., Madison, Pa. Advanced Reactors Div.). Contract AT(30-1)-4135. 31p. Dep. CFSTI.

Activities in programs to improve commercially available Type 316 austenitic stainless steels for use as cladding for LMFBR fuel pins are reported. Work on stress rupture, and uniaxial and biaxial creep testing of air melted stainless steel continued. Additional low cycle high strain fatigue tests were delayed pending proof testing of a new specimen design. Twelve lots of vacuum melted Type 316 stainless steel tubing representing three melting practices, two grain sizes, and two conditions, e.g., 20% cold worked and solution annealed, were received and accepted. Microcharacterization and mechanical property testing were initiated on these materials. An order was placed for vacuum melted planetary swaged tubing to be used in the characterization studies. Ten lots of double vacuum remelted Type 316 stainless steel tubing for the Oxide Fuel Element Development Program (19 pin encapsulated assembly) were received and accepted. Double vacuum melted tubing for the 37 pin assembly was ordered. The weldability subtask continued. The first series of weldability studies has been completed on annealed Type 316 stainless steel tubing. The second series of weldability studies will be conducted on 15 to 20% cold worked tubing. (auth)

**14666** TALKING OF THE STRUCTURAL MATERIALS FOR POWER REACTORS IN JAPAN, TODAY. PART 5. Mishima, Yoshitsugu (Tokyo Univ.). Shin Kinzoku Kogyo; 14: 336-45 (Dec 1969). (In Japanese).

The problems concerning materials for both experimental and prototype fast reactors are discussed with special emphasis on mass transfer of carbon from the cladding tube to vessel material in the former and cladding and heat exchanger materials in the latter. The project of iron making and reactor development in Japan, especially from the point of view of reactor safety is discussed. Zirconium-water reaction problems are briefly surveyed. (NSA of Japan)

**14667** HIGH PRESSURE EFFECTS WITHIN THE URANIUM–CARBON SYSTEM. Krupka, Milton C. (Los Alamos Scientific Lab., N. Mex.). Amer. Ceram. Soc. Bull.; 48: 1133-6 (Dec 1969).

The effect of high pressures on compounds in the U–C system was studied at temperatures up to 1500°C. Resistance vs pressure measurements at ambient temperature were made to 50 kbar. Single and diphasic compositions ranging from $UC_{0.97}$ to $UC_{2.11}$ were studied. Electrical resistance vs pressure experiments at ambient temperature produced curves whose basic shape was, in general, similar for all compositions. Experimental studies made of the high temperature-pressure methods of producing $U_2C_3$ clearly demonstrated that a rapid high yield synthesis of $U_2C_3$ is possible and that the $UC_{1.5}$ (equimolar UC + $UC_2$) composition region is the most fruitful in terms of time, temperature, and yield. At 15 kbar and a constant reaction time, a yield vs temperature curve was established for $U_2C_3$. Acceleration of the reaction rate above that obtained by normal annealing techniques was observed. The very narrow homogeneity range of $U_2C_3$ was confirmed by the constant lattice parameters obtained. The value 8.0902 ± 0.0005 Å was obtained for the best 18 specimens with individual values ranging from 8.0879 to 8.0914 Å. (BBB)

**14668** WELDING METHOD FOR SEALING A NUCLEAR FUEL ELEMENT. Komuro, Kojiro (to Hitachi Ltd.). Japanese Patent 1969-24250. 14 Oct 1969. Filed 20 Apr 1966.

The method proposed is for welding a plug on the end of a fuel element cladding tube made of zirconium or its alloy. The advantage obtained was the prevention of local corrosion at the weld by high-temperature steam; further, the welding can be done easily and efficiently. The cladding tube was subjected to autoclave test, and oxide film was formed on the surface. With the presence of this oxide film, the cladding tube, complete with nuclear fuel, was sealed by welding a plug on the end. At the time, the solid solution of the oxide film occurred at the heat-affected zone in the welding. This surface layer of oxide solid solution, which is otherwise susceptible to corrosion, was removed by a suitable means. (NSA of Japan)

**14669** THE INFLUENCE OF REDUCTION RATIO ON THE DEVELOPMENT OF TEXTURES AND TEXTURE GRADIENTS IN ZIRCALOY TUBES. Tenckhoff, E. (Oak Ridge National Lab., Tenn.). Z. Metallk.; 61: 64-71 (Jan 1970). (In German).

Zircaloy tubes which were drawn with different sequences in reduction exhibited different final textures. If the reduction of the wall prevailed, the normal to the basal planes was parallel to radial directions. If the reductions of wall thickness and diameter were equal, a fiber texture was formed with a random distribution of basal poles in the radial-tangential plane. Preferred reduction of the diameter led to a preferred tangential alignment of the basal poles. This relation must be considered for each layer in the tube wall. Deviation from this behavior may be attributed to textures present prior to the tube drawing process. The observations may be explained based on a model taking into account the effective principal forces and principal strains. The results indicated that the texture formation may be deliberately programmed such that the mechanical properties of Zircaloy tubes are favorably influenced. (auth)

**14670** SOLID SOLUTION EFFECTS IN Nb–BASE Ta AND Nb–BASE Mo SOLID SOLUTION. Peters, Bruce Charles. Houghton, Mich.; Michigan Tech. Univ. (1968). 158p. Thesis.

The substitutional solid solution strengthening effects in Nb, Nb–Ta, and Nb–Mo alloys were studied as a function of composition, temperature, and strain rate by means of both tension and compression tests. The intent was to compare the solid solution effects of Ta in Nb (zero size difference, large modulus difference) with those of Mo in Nb (large size and modulus difference). This comparison is made in terms of the relative effects of the size effect and modulus effect as proposed by Fleischer. It was found that both the athermal strengthening and the stress-strain behavior show a very pronounced effect with Mo additions and a small (if any) effect with Ta additions. The athermal properties are shown to be well correlated with the atomic misfit parameter with no observable effect due to the elastic modulus interaction. The effect of Ta additions to Nb on the room temperature stress-strain behavior was negligible; however, the addition of as little as 1% Mo completely masked the three stage hardening behavior of the pure Nb. It would appear that small additions of Mo to Nb have the same effects as decreasing the temperature or increasing the strain rate, i.e., to mask the three stage behavior. The absence of solid solution effects in the Nb–Ta system was found to continue over the entire temperature range of investigation (4.2 (twinning) 77 → 373°K) and at all composition (0–100% Ta). From this it would appear that Nb–Ta alloys behave similarly to a pure metal with the shear modulus of the alloy. In contrast to the Nb–Ta system, the Nb–Mo system shows very marked effects over the entire temperature range (same as Nb–Ta) and at all compositions (0 to 20% Mo). It was observed that at low concentrations of Mo in Nb, i.e., up to 5%, and at low temperatures (77°K) there was an absence of solid solution strengthening. This absence of effects was not found at higher temperatures or concentrations. The behavior is interpreted in terms of the impurity hardening theory and it is shown that a transition occurs at low concentrations between the mechanism(s) operating in the pure material (Nb) and that operating in the high Mo alloys. The effect of interstitial oxygen on the room temperature strength of Nb and selected Nb–Ta alloys was observed to be quite pronounced, typical of interstitial effects in bcc metals. The observed behavior followed that predicted by Fleischer for an asymmetric defect in the bcc lattice. The strain rate sensitivity for Nb–Ta alloys, i.e., the change in stress for a given change in strain rate, behaved in a similar manner to the other measured properties. It appeared to be affected only by the shear modulus of the alloy. Over the temperature range studied the bcc metals characteristically show a maximum in the strain rate sensitivity versus temperature curve, this was also found in this investigation. However, in the case of Nb–Mo alloys the temperature at which the maximum occurred was significantly and systematically affected by alloy additions. It moved from <77°K for pure Nb to 240°K for Nb–20% Mo. This phenomenon is discussed qualitatively in terms of its possible origin. Twinning was observed in all cases during deformation at 4.2°K. The observed twinning phenomena showed an apparent positive temperature dependence of the stress. This is discussed

in terms of the continual mechanical twinning theory. (Diss. Abstr.)

**14671** DEVICE FOR WELDING A NUCLEAR FUEL ELEMENT. Komuro, Kojiro (to Hitachi Ltd.). Japanese Patent 1969-18837. 14 Aug 1969. Filed 8 Apr 1966.

A device is described for welding a plug into the end of a nuclear fuel element. The advantages of this device are a small welding chamber, reduced time for evacuating and filling the chamber with inert gas, reduced amount of inert gas consumption, and efficient welding. The device consists of the following: a welding chamber, which contains the end of a fuel element and a plug to be inserted into it; a means, inside the chamber, to hold the plug; a means to rotate the fuel element and the plug, keeping the chamber air tight; a welding torch inside the chamber; a door on one side of the chamber on which a viewing window is fixed; a means, outside the chamber, to bring the plug in contact with the end of a fuel element; and a means, outside the chamber, to operate the welding torch. The welding is done by rotating the fuel element end and plug which are in contact with each other. (NSA of Japan)

**14672** FORMATION OF SUPERSATURATED TERNARY SOLID SOLUTIONS DURING FAST COOLING. Polesya, A. F.; Stepina, A. I. (Dnepropetrovsk State Univ., USSR). Fiz. Metal. Metalloved.; 27: 885-9(May 1969). (In Russian).

The effects of fast cooling on the formation of supersaturated ternary solid solutions were studied. Alloys studied included Al–Mn–W, Al–Mn–Mo, Al–Mn–Cr, Al–Cr–W, Al–Cr–Mo, Al–Mn–Zr. (tr-auth)

**14673** NOTE ON THE RADIOMETRIC DETERMINATION OF TOOL WEAR IN STEEL WIRE DRAWING. Holzhey, J.; Krueger, G.; Vogel, J.; Giehler, W. (Forschungsinstitut fuer NE-Metalle, Freiberg, Ger. Drahtforschungsstelle, Leipzig). Isotopenpraxis; 5: 345-9(Sep-Oct 1969). (In German).

A reliable and very sensitive radiometric technique for determining the tool wear in steel wire drawing is described. Compared with the radiometric measuring techniques known from literature, the proposed technique is less time-consuming and allows carrying out extended series of measument at an expense not too high. Using this technique, it is possible to avoid cumbersome production-scale experiments and, contemporaneously with this, to obtain essentially more exact information on wear under various conditions of drawing. (auth)

**14674** EXPERIMENTAL STUDIES ON THE CORRESPONDENCY BETWEEN DEFECTS AND NON-DESTRUCTIVE TEST IMAGE AND THE EFFECT OF DEFECTS ON TENSILE STRENGTH OF STEEL PLATES AND WELDS OF A REACTOR PRESSURE VESSELS. 4. Yosetsu Gijutsu; 17: No. 10, 91-5(Oct 1969). (In Japanese).

A variety of welding defects was evaluated by nondestructive tests such as radiation penetration, sonic and magnetic inspection, and visual observation of the fractures. It was found that the effect of defects on tensile strength is governed by the degree of notch effect on brittleness. The transition region of fracture is from 0 to −50°C, regardless of the type of defect. The transition region of breaking stress is below −100°C, and above this point, the tensile strength is similar to that in reactor-grade welds, regardless of the type of defect. The notch effect of excess metal is the same degree as that in slag inclusion. When low stress breaking occurs, the application of linear breaking dynamics is possible for the defects. (NSA of Japan)

**14675** DESIGN, FABRICATION, AND TEST OF A BORON WING STRUCTURE. August, A.; London, A.; Ludwig, W. (Grumman Aerospace Corp., Bethpage, N. Y.). pp 17-27 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

A section of aluminum wing structure was redesigned using boron-epoxy composite. It represents the first application of this material to a pressurized fuel carrying section of wing. The design tradeoffs, material properties, joint test data, manufacturing processes and preliminary test data developed during the program are presented. The results of this effort have provided a broad technology base for the application of the material to future aircraft structures. (auth)

**14676** TITANIUM INVESTMENT CASTINGS. Parkinson, Fred L. (Boeing Co., Seattle). pp 201-18 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

The present state-of-the-art related to titanium castings is described with special emphasis on the mechanical properties of Ti–6Al–4V investment castings. The process has been sufficiently developed such that complex configurations can be produced with good dimensional control and, in general, high mechanical properties. Properties investigated and reported include ultimate tensile strength, .2% yield strength, % elongation, % reduction in area, compression yield strength, ultimate shear strength, yield and ultimate bearing strengths, precracked Charpy impact strength, plane strain fracture toughness, stress corrosion resistance, and fatigue properties. (auth)

**14677** METALLURGICAL AND STRUCTURAL ASPECTS OF DIFFUSION BONDED TITANIUM HONEYCOMB SANDWICH. Emero, D. H.; Mejia, M. J. (Stresskin Products Co., Santa Ana, Calif.). pp 219-29 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

A two-phase process is reviewed that produces diffusion bonded titanium honeycomb sandwich panels on a production basis. The mechanics and metallurgy of the diffusion bonding process are discussed. Static and fatigue test data are presented which demonstrate the structural integrity of this recently developed sandwich product. Comparative examples are presented which illustrate the weight saving potential of this sandwich in typical aerospace hardware applications. (auth)

**14678** STRUCTURAL MATERIALS FOR THE SST. Fielder, L. J. (Boeing Co., Seattle). pp 242-52 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

Improvements in range–payload capability were obtained in the aircraft model 2707-300 primarily by optimizing both the configurational arrangement and types of construction utilized in the airframe. Primary emphasis was placed on the development of techniques to fabricate efficient honeycomb and trusscore sandwich panels for structural boxes in the wing and empennage. Criteria critical to the selection of a material for these panels included high fracture toughness and resistance to stress corrosion, good weldability, stability of mechanical properties on elevated temperature exposure, and availability in long lengths. Based on these requirements, the principal structural material selected was continuously rolled Ti–6Al–4V sheet. For the fuselage, continuously rolled Ti–6Al–4V sheet was specified for skin and formed stringers; Ti–6Al–4V in the annealed or solution treated and aged condition was specified for extruded stringers. PH 14–8 Mo stainless steel will be used extensively on brazed full depth honeycomb wedges for leading and trailing edges of the wind and empennage. (auth)

**14679** FABRICATION AND PROPERTIES OF BOAT-EVAPORATED PERMALLOY THIN FILMS. Carson, Kent Randall. Houston, Tex.; Rice Univ. (1969). 253p.

Thesis.

All major aspects of the boat evaporation of permalloy thin films were characterized. The steps involved in transforming deposition conditions to magnetic film properties are described. Characteristics of operation of the evaporation and vacuum equipment were evaluated first. This included analyses of substrate temperature, the magnetic field, the evacuation parameters, and the cleaning, orientation, heating rate, and temperature of the boats. The geometry of the charge was considered and various techniques for attaching it to the boat were tried. The bulk properties and surface condition of typical glass substrates were studied extensively, in particular, replica electron microscopy was used to compare several of the methods available for predeposition cleaning. The next step was to chart the functional dependence of the gross physical film properties on the deposition parameters. The average film thickness and composition were related to the weight and composition of charge, the power applied to the boat, the charge geometry, the residual gas pressure, and the cleanliness of the boat. A technique was developed to sample the vapor as a function of time. The effects of varying deposition conditions on the formation of composition gradients through the film thickness were studied in this manner. The deposition kinetics of boat evaporation were inferred from the forementioned body of data, from additional experiments, and from theoretical considerations. Specifically analyzed were the formation of the Ni–Fe–W ternary alloy and its effect on vapor emission, the rate of evaporation, and the partial pressures of Ni and Fe. The directional distribution of the intensity and composition of the vapor was studied and found to differ substantially from cosine law behavior.

Factors affecting condensation of the evaporant and contamination of the deposit by residual gases were also considered. Micromagnetic energetics bridge the gap between physical and magnetic film properties. The individual energy parameters were briefly defined and the ways in which they can be of use in thin film research were outlined. Magnetic film properties were correlated with physical properties in the following experiments: a Lorentz microscope study of the direction of the magnetization at the edge of a film and at other discontinuities; a rather extensive set of annealing experiments in which changes in $H_c$, $H_k$, and $\alpha_{50}$ are related to structural changes in the films; and an experiment to show why the magnetic film properties are so strongly affected by deposition in poor vacuum. (Diss. Abstr. Int., B)

**14680** PREPARATION OF CARBON-FREE BORIDES OF CHROMIUM, MOLYBDENUM, AND ZIRCONIUM BY THERMAL METHOD. Meerson, G. A.; Gorbunov, A. E. Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 2075-82(Dec 1969). (In Russian).

Carbon-free borides of chromium, molybdenum, and zirconium were prepared by heating boride powders. Best results were obtained with specimens of chromium boride at 1800°C, molybdenum boride at 1900°C, and zirconium boride at 1900°C. (tr-auth)

**14681** METHOD OF PRODUCING SHEETS. (to Nuclear Materials and Equipment Corp.). British Patent 1,180,807. 11 Feb 1970. Priority date 20 Jul 1966, United States.

Methods of reducing the thickness of stainless steel bodies containing substantial quantities of boron are described. A typical use for the methods is in fabrication of sheets for reactor control rods. The stainless steel billet to be reduced is enclosed in a jacket of material which retains its strength at 1100 to 1200°C. The package is heated to about 1100°C and rolled to the desired thickness. (J.R.D.)

**14682** THE NUCLEAR RAW MATERIALS INDUSTRY IN FRANCE: RECESSION OR EXPANSION? Mabile, Jacques (CEA, Paris). Energ. Nucl. (Paris); 11: 541-8(Dec 1969). (In French).

The present situation of the nuclear raw materials industry in France includes an over-capacity of production and conversion facilities for uranium and plutonium due to reduced military and industrial demands for these products. However, a growing world market exists. Further expansion of the European and world markets is recommended so that France can maintain her strong position in the conversion of raw nuclear materials. (auth)

**14683** TECHNIQUE FOR CHEMICALLY POLISHING SODIUM. Isaacs, H. S.; Singer, R. M. (Brookhaven National Lab., Upton, N. Y.). J. Nucl. Mater.; 34: 197-201(Feb 1970).

A method is given for chemically polishing sodium in preparation for metallography. A polished surface was obtained when sodium was agitated in a mixture of 5 to 50% methanol in acetone, but the luster decreased with increased amounts of alcohol. (G.M.C.)

**14684** HIGH-PRESSURE SYNTHESIS OF LUTETIUM DI-ANTIMONIDE. Eatough, Norman L.; Hall, H. Tracy (Brigham Young Univ., Provo, Utah). Inorg. Chem.; 9: 416-17(Feb 1970).

No phases except $LuSb_2$ were found in the Lu–Sb system up to 90 kbars and 1500°C. The $LuSb_2$ was formed at 73 kbars and 1000°C. The powder pattern indexed to an orthorhombic structure with lattice constants of a = 5.935 ± 0.006, b = 3.244 ± 0.004, and c = 7.885 ± 0.009 Å. (M.C.G.)

**14685** EFFECT OF REDUCTION TEMPERATURE ON THE SINTERING ABILITY OF MOLYBDENUM POWDERS. Kostich, E.; Panichkina, V. V.; Skorokhod, V. V.; Khrienko, A. F. (Boris Kidric Inst. of Nuclear Sciences, Belgrade. Inst. of Problems in Material Studies, Kiev). Porosh. Met., Akad. Nauk Ukr. SSR; No. 12, 29-31(Dec 1969). (In Russian).

The investigated molybdenum powders were obtained by reduction of $MoO_3$ in hydrogen at 750, 850, and 950°C. The powders obtained at 750° were the most active at sintering. The activity during sintering is explained by different dispersity of the powders, which is determined by the magnitude of the specific surface. The parameters of substructure determined by broadening reflexes (110) and (220) proved to be similar to all the powders. (auth)

**14686** EXPLOSIVE WELDING. Proceedings of a Select Conference at Hove, England, 18–19 September 1968. London; Welding Institute (1969). 83p. 57s. 6d. (CONF-680969).

Thirteen papers were presented at the conference. An abstract was prepared for one paper. Papers for which no abstracts were prepared are concerned with explosive welding of various materials and examination of the welds. (J.R.D.)

*For an abstract of one paper see: 14687.*

**14687** EXPLOSIVE WELDING OF NUCLEAR REACTOR MATERIALS. Verzeletti, G.; Montagnani, M.; Beghi, G.; Golinelli, P. (EURATOM, Ispra, Italy). pp 1-8 of Explosive Welding. London; Welding Inst. (1969).

From Conference on Explosive Welding, Hove, England. See CONF-680969.

The explosive welding of nuclear reactor materials, was the subject of an experimental program. The following combinations of materials have been successfully welded to each other in this way: Zr 2–AISI 304 L, Zr 2.5% Nb–AISI 304 L, Zr 2.5% Nb–UNI C 10, SAP–SAP, SAP–AISI 304 L, Al 2% Si–AISI 304 L, Zr 2–Zr 2, AISI 316 L–AISI 316. Experimental work was started by welding two plates to each other; subsequently the welding of two cylinders, from diameter 8.7 mm up to 110 mm, was executed. The main purpose of this experimental program is the development of welds of SAP or Zircaloy pressure tubes to their extension pieces in steel and of fuel element cannings to their end plugs. Destructive and non-destructive tests showed an excellent reproducibility, a good leak tightness, and a mechanical resistance equal to that of the weaker material. Microscopic examination of the weld did not show the presence of brittle intermetallic particles, which is in accordance with the good ductile properties of the weld. (auth) (UK)

**14688** URANIUM ALLOY. Blanchard, P.; Virot, A.; Lehmann, J. (to Commissariat a l'Energie Atomique). Canadian Patent 830,418. 23 Dec 1969. Priority date 21 Jul 1964, France.

Ternary and quaternary natural uranium alloys are described as fuel elements particularly for use in pressure $CO_2$–cooled reactors. Fairly small proportions of Mo, Si, Sn, Cr, Yb are alloyed with U. Increased grain size with improved resistance to deformation are claimed for such tubular elements enclosed in metal cans. High specific power is another advantage. The process of preparing the fuel elements is outlined. (F.S.A.)

**14689** PROGRAMMED GAS TUNGSTEN-ARC WELDING OF TAPER THICKNESSES AND STEPS IN 6Al-4V TITANIUM. Stiles, A. A.; Bowman, J. D. (General Dynamics Corp., Fort Worth, Tex.). Weld. J. (N. Y.); 49: 28-37(Jan 1970).

A simple low cost system concept has been developed which can be used to program the gas tungsten-arc process to weld taper and stepped joint designs. The system was designed to be used with 6Al-4V titanium and other weldable materials up to 0.250 in. thick. The design is based on coordinated welding and fixture parameters developed as functions of material thickness. The parameters are developed to give an approximate linear relationship to material thickness. These data are utilized to program a friction drive coordinated pulley system which automatically and uniformly changes the welding parameters with reference to position along the weld joint. The approach and resulting programming system offers advantages such as: simple procedures for all personnel; accurate, consistent, and reproducible data; and a low cost. (auth)

## *Properties Evaluations*

*Refer also to abstracts 14157, 14205, 14207, 14210, 14213–14215, 14219–14221, 14675, 14907, 14915, 14931, 14987, 15385, and 15407.*

**14690** (AI-AEC-12896) THERMAL GRADIENT EFFECTS ON STRESS-RUPTURE BEHAVIOR OF THIN-WALLED TUBING. Shively, J. H.; Mahoney, M. W. (Atomics International, Canoga Park, Calif.). 2 Jan 1970. Contract AT(04-3)-701. 33p. Dep. CFSTI.

The results of stress-rupture tests of internally heated and pressurized thin-walled tubes of Types 304 and 316 stainless steel are presented. The tubes were immersed in high-purity sodium at 1200°F at a flow rate of 20 ft/sec. Heat fluxes of 0.8 and $1.0 \times 10^6$ Btu/ft$^2$-hr passed through the wall, corresponding to a heat rate of 18.4 and 23 kW/ft, respectively. The heat flux was applied in two modes: steady and cyclic. The cyclic mode involved on-off cycles of the heater for three different time periods: 2 min, 12 min, and 72 min. The purpose of the tests was to examine the separate and combined effects on creep behavior of stainless steel fuel rod cladding from thermal gradients through the wall, repeated thermal stress relaxation, cycle rate, mass transfer, and alloy type. Steady internal heating had little effect on creep behavior, even though evidence of mass transfer was found on the surface for times up to 600 hr. The data correlate with that obtained in isothermal static-sodium creep-rupture tests for the maximum temperature along the center of the tubing thickness. Cyclic heating reduced the life by a factor of 2, and produced large changes in the microstructures, strain profiles, and strain at failure. The amount of heat flux did not substantially alter the cyclic effect, but an increase in the cyclic rate reduced the life of cold-worked Type 304 stainless steel. The effect on annealed Type 304 stain-

less steel was about the same as for the cold-worked alloy. The life of cold-worked Type 316 stainless steel was longer than for cold-worked Type 304 stainless steel, at otherwise identical conditions. An increase in the cycle rate increased the life of cold-worked Type 316 stainless steel. The reduced life, the effects of cycle rate, and the sensitivity to surface defects are explained semiquantitatively, in terms of an enhanced creep mechanism involving repeated stress relaxation of thermal- and creep-induced residual stresses. The results are discussed in terms of their implications for reactor fuel element design criteria. (auth)

**14691** (BARC-447) DIFFUSION OF $^{95}$Nb INTO COPPER. Saxena, M. C.; Sharma, B. D. (Bhabha Atomic Research Centre, Bombay (India)). 1969. 13p. Dep. CFSTI (U. S. Sales Only).

The theories of solute diffusion in noble materials are based on size effects or on solute-vacancy interactions which involve use of valence. The valence of transition metals for screening purposes are not well established, and as such solute-vacancy interaction terms cannot be evaluated with confidence. There is a lack of sufficient data on the diffusion of transition elements in monovalent metals. The diffusion data for $^{95}$Nb into copper indicate the diffusion of Nb in Cu is similar to those of Fe, Co, and Ni in copper. (auth)

**14692** (GEMP-1013, pp 53-95) FAST BREEDER REACTOR ADVANCED FUEL ELEMENT CLADDING FABRICATION. Frank, R. G.; Tarr, C. O. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Work during this report period was directed toward the evaluation of unalloyed molybdenum sheet produced by five commercial vendors. None of the commercial material was considered to meet nuclear quality requirements. Bend test results obtained with these materials emphasize the importance of purity on bend ductility. Carbon additions apparently improved the ductile-brittle transition temperature (DBTT) of the unalloyed molybdenum. Although the improvement in the DBTT is probably due to deoxidation reactions of the added carbon, the favorable effect of carbon on grain boundary cohesion may also be a factor. In this series, the method of consolidation (powder metallurgy versus arc-cast process) did not appear to influence product ductility. The method of cleaning the sheet prior to welding appeared to influence weld quality. As could be anticipated, bend test specimens at a slow punch speed resulted in greater bend ductility of the welds than achieved at a fast punch speed; increasing the thickness of the bend specimen also reduced the bend angle for fracture. For small bend angles, autographically recorded load-strain charts appeared sufficiently accurate for acceptance-rejection decisions. With a narrower weld fusion zone, the electron-beam welding process appeared to permit a slightly greater bend angle in the unalloyed Mo than TIG welding. The direction of the bend crease relative to the sheet rolling direction was observed to markedly influence bend test ductility with the least ductility observed when the bend crease was parallel to the sheet rolling direction. Acceptability of the commercially produced unalloyed Mo sheets for nuclear applications involving welding was concluded to be fair to poor. Four of the six lots of sheet products evaluated would be rejected for weld porosity and one for weld cracking. Although the remaining lot of material showed sound welds, the weld ductility was poor. A tube drawing procedure was developed for the production of refractory metal tubing in unusual physical dimensions or from very strong alloys. Examples are given of work completed with very heavy walled W-25Re-30Mo alloy tubing, and very small bore diameter (0.025 cm) tubing. The new process uses sacrificial material to shield the desired product from the high surface stresses developed at the usual die to work piece interface. This approach avoids the usual problem of cracking due to grain boundary separation during the tube drawing operation. (auth)

**14693** (GEMP-1013, pp 115-37) ADVANCED LONG-LIFE REACTOR FUEL CLADDING AND STRUCTURAL MATERIALS DEVELOPMENT. Frank, R. G.; Bartos, J. L. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Characterization of the creep rupture properties of the two 55 kg heats of Fe-20Ni-5Cr-10Mo alloy continued. A Larson-Miller parametric representation of the data indicated the rupture lives of solutioned and aged material from heats MS-70 and MS-71 exceed those of annealed Type 316 SS for all stresses in the 550 to 850°C temperature range. Preliminary tests of solution treated and aged Fe-Ni-Mo alloys (heats M-389 and M-414) suggest they are as creep resistant as the Fe-20Ni-5Cr-10Mo composition. Four billets of high purity Type 316 SS have been extruded, chemically analyzed, and examined for inclusion content. Based on this data, heat MS-74 has been chosen as the primary reference alloy and material has been fabricated for mechanical property, fuel compatibility, and irradiation effects evaluation. A series of Co-base alloys was prepared to determine the effect of quaternary element additions on the strength and ductility of Co-Fe-Ta alloys. Slow bend test results on heat M-446 (Co-9Fe-0.6Ta) suggest solutioning and aging tend to embrittle Co-Fe-Ta alloys at elevated temperatures. (auth)

**14694** (GEMP-1013, pp 139-47) PHYSICAL METALLURGY OF FAST BREEDER REACTOR CLADDING MATERIALS AND REFRACTORY METALS. Collins, C. G.; Bohlander, K. M. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Results of studies of thermal-mechanical treatments on potential LMFBR fuel-cladding materials indicated that the optimum useful ductility in 19-9DL—and probably other stabilized alloys—is obtained at annealing temperatures near but less than that at which optimum strength occurs. Treatments involving temperatures at the low end of the annealing range provided small grain sizes and generally large elongations in tests up to 650°C but proved relatively weak at 760°C. In related work, general planetary swaging procedures were worked-out and were successfully applied to fabrication of specimen tubes of the 12R72HV alloy. (auth)

**14695** (GEMP-1013, pp 225-63) PHYSICAL AND MECHANICAL PROPERTIES OF REACTOR MATERIALS. Conway, J. B.; Flagella, P. N. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

A program was initiated to determine the biaxial strain-time behavior for pressurized AISI Type 316 stainless steel tubing. Tube samples, 0.635 cm OD × 0.0406 cm wall, were tested at 650°C in argon and air atmospheres at various stress levels. Circumferential strain values were obtained at various intervals of time by interrupting the tests to make diameter measurements at room temperature. Results to date for annealed material indicate that the creep resistance is less in an argon atmosphere than when tested in air. Data obtained for two lots of annealed Type 316 stainless steel tested in argon show significant differences in the creep resistance. This difference is attributed to the differences in microstructure. For the same temperature and stress conditions, higher strain values were obtained for a biaxial stress condition of 1:3 as compared with 1:2. Uniaxial creep data for commercial annealed Type 316 stainless steel sheet show an abrupt change in creep rate after 200 to 400 hours in tests at low stress values at 650°C in both air and argon atmospheres. Creep-rupture tests of wrought powder metallurgy W-30Re-40 Mo (at. %) were performed at 2200°C and 0.352 kg/mm$^2$ in hydrogen to evaluate the effect of various processing purification treatments. Significant differences in the creep resistance were obtained consistent with the various purification treatments and resulting microstructure for the material. The samples with the largest grains (fewest grain boundaries) were the most creep resistant. Initial thermal diffusivity and thermal conductivity data for $UO_2$ are presented as a result of the round robin program being coordinated by GE-NSP. All test samples have been fabricated and sent to the various laboratories involved. (auth)

**14696** (GEMP-1013, pp 265-310) EVALUATIONS OF THE PLASTIC FATIGUE PROPERTIES OF HEAT-RESISTANT ALLOYS. Conway, J. B. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

An interesting correlation procedure for low-cycle fatigue data has been defined relating the elastic strain range to the strain-hardening exponent measured in a short-term tensile test. This correlation coupled with the plastic strain range equation identified previously allows the total strain range versus fatigue life behavior to be predicted. All previously reported tension-hold-only data for 304 stainless steel at 650°C and a strain rate of $4 \times 10^{-3}$ sec$^{-1}$ have been brought into correlation by making use of a stress amplitude versus time-to-fracture plot. This correlation is shown to have an interesting relationship with no-hold-time data. Some additional studies have been made of the short-term tensile test procedure based on the use of hourglass-shaped specimens. It has been shown conclusively that the use of hourglass-shaped specimens leads to a more valid measurement of certain tensile properties since the actual strain rate is held constant throughout the test. A program was initiated to evaluate the low-cycle fatigue and short-term tensile behavior of Incoloy 800 to 760°C. Both mill-annealed and solution-annealed material are being tested in air at strain rates of $4 \times 10^{-3}$ and $4 \times 10^{-4}$ sec$^{-1}$. Initial results indicate that the low-cycle fatigue characteristics of solution-annealed Incoloy 800 are quite similar to those of annealed AISI Type 304 stainless steel. Hold-time testing of annealed AISI Type 316 stainless steel has been initiated. These results are completely consistent with the hold-time correlation developed using the 304 stainless steel data. Short-term tensile testing of Incoloy 800 was initiated. Tensile strengths and duc-

tilities at 650°C and a strain rate of $4 \times 10^{-3}$ $sec^{-1}$ are noticeably higher than similar data for 304 stainless steel. The evaluation of two different methods of biaxial fatigue testing was continued. A computer-aided elastic stress analysis was used to establish a promising geometry for a cruciform-shaped specimen. In addition, a technique to perform biaxial testing on thin-walled tubes was identified and a tentative program plan was selected. (auth)

**14697** (GEMP-1013, pp 311-37) ADVANCED PRESSURE VESSEL MATERIALS. Robertshaw, F. C.; Stephan, H. R. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Activities in a program to determine the applicability of high-strength steels and alloys to reactor pressure vessels are reported. Information is included on thermal and mechanical properties of Ni-Cr-Mo steel, PH13-8Mo precipitation hardening steel, and fatigue testing of high-strength steels. (J.R.D.)

**14698** (GEMP-1013, pp 379-405) FAST BREEDER REACTOR CONTROL, SHIELD, AND REFLECTOR MATERIALS DEVELOPMENT. Van Houten, Robert; Kennedy, M. D.; Amos, J. C. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

The first set of $B_4C$-316 SS diffusion couple test data indicate higher reaction rates than were projected from earlier, non-equivalent tests. These test results indicate that the operating time-temperature safety margin is even less than the rather narrow margin previously anticipated. A 1000-hour test of a 3.8-cm-diameter Mo-clad Ta control rod segment in 550°C sodium flowing (in a 304 SS loop) at 3 meters/sec was successfully completed. Post-test inspection showed no change in appearance, weight, dimensions, or clad-to-core bonding. (auth)

**14699** (IS-T-343) DETERMINATION OF DIFFUSION COEFFICIENTS IN A LIQUID In-Sn SYSTEM. Wenger, John Charles (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 67p. Dep. CFSTI.

Thesis.

Values of the diffusion coefficient have been determined over the entire composition range of the indium-tin system at 300°C. A variation of the capillary reservoir technique was used. Values of the diffusion coefficient, D, range between $2.33 \times 10^{-5}$ $cm^2/sec$ and $3.15 \times 10^{-6}$ $cm^2/sec$ depending on concentration. A minimum occurs in the middle concentration range. Results of diffusion runs indicate density convection and it is believed the indium-tin system goes through a minimum density in the 20 to 30% indium range. No density data are recorded for the indium-tin system to establish such a minimum. (auth)

**14700** (KAPL-3826) EFFECT OF WARM PRESTRESSING ON PRESSURE VESSEL STEEL. Andrews, W. R.; Baldwin, E. E. (Knolls Atomic Power Lab., Schenectady, N. Y.). Jul 1969. Contract W-31-109-eng-52. 45p. Dep. CFSTI.

An experimental study of the effects of warm prestressing on the fracture strength of notched and fatigue-cracked bend bars of A508 Class 2 low-alloy steel was conducted. The steel was tested in four conditions simulating four thickness fractions of a 23½ in. thick forging. Three load-temperature paths investigated were preload-cool-fracture, preload-cool-unload-fracture, and preload-unload-cool-fracture. The fracture strengths of the prestressed bars were compared with the fracture strengths of unprestressed bars. The benefits of prestressing for each load-temperature path decreased in the order listed, although prestressing was always beneficial. The benefits also decreased with decreasing fracture-test temperature relative to the reference transition temperature (RTT). Aging at 500°F after prestressing produced a small deleterious effect which may have been caused by relaxation of residual stresses at the crack tip. (auth)

**14701** (NVO-193-9) EFFECTS OF OUT-OF-ROUNDNESS AND RESIDUAL STRESSES ON RING REINFORCED STEEL SHELLS. Final Report. Greimann, L. F.; DeHart, R. C.; Franz, C. R. (Southwest Research Inst., San Antonio, Tex.). 23 Oct 1969. 103p. Dep. CFSTI.

For Committee of Steel Plate Producers, American Iron and Steel Inst., New York.

Results of investigations are presented concerning the effects of fillet welds, residual stresses and out-of-roundness on ring stiffened cylindrical steel shells used as casing in holes for underground nuclear tests. The models used in the investigation are described. Analytical results are presented and compared with experimental data. (J.R.D.)

**14702** (ORNL-TM-2809) PREDICTING THE PERFORMANCE OF ARC-CAST TUNGSTEN CAPSULES CONTAINING ALPHA-EMITTING ISOTOPES AT THERMIONIC TEMPERATURES. Swindeman, R. W. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 40p. Dep. CFSTI.

The performance of arc-cast tungsten under conditions typical of a nonvented capsule containing $^{244}Cm$ was studied. Creep data available in the literature were used to generate several flow models describing the temperature and stress dependence of the creep rate or the time to a specific strain. These flow equations were then combined with a cumulative creep model and the temperature-stress profile typical of a fuel capsule. Solution of several such models indicated that the predicted performance of arc-cast tungsten is not particularly sensitive to either the flow equation or the cumulative creep model to longer than 10,000 hr over the range from 1600 to 2000°C. (auth)

**14703** (SC-CR-68-3586) DETERMINATION OF THE WORK FUNCTIONS OF SELECTED METALS AND INORGANIC COMPOUNDS. (Denver Research Inst., Colo.). Apr 1968. Contract 57-1061. 36p. Dep. CFSTI.

For Sandia Labs., Albuquerque, N. Mex.

The work functions of titanium, erbium, vanadium, and chromium were determined both thermionically and photoelectrically. The work functions of the titanium-hydrogen and the erbium-hydrogen systems were determined photoelectrically as a function of hydrogen composition. In the photoelectric work the metals were evaporated onto a nickel substrate under very high vacuum conditions. The work function of the nickel substrate was determined before the other metals were evaporated. Results are analyzed and equipment used in the measurements is described. (J.R.D.)

**14704** (SC-RR-69-828) COMPUTER SIMULATION OF STRESS CORROSION CRACKING. McLaughlin, Bruce D. (Sandia Labs., Albuquerque, N. Mex.). Jan 1970. 39p. Dep. CFSTI.

By assuming that the electrochemical oxidation mechanism of crack propagation is not supplemented by mechanical fracture or plastic deformation during the early stages of crack growth and that the equilibrium rate of a charge transfer half-reaction, occurring at the interface between two phases, is dependent upon the local surface tension at the point of reaction, it is demonstrated that it is possible to account for the general aspects of stress corrosion cracking such as the existence of an incubation period, the existence of a threshold stress, the variation of incubation time with overpotential, and the variation of incubation time with applied stress. (auth)

**14705** (TID-25337) SYNOPSIS OF THE EFFECTS OF ENVIRONMENTS ON THE MECHANICAL PROPERTIES OF 304 AND 316 SS. MSAR Information Chart 69-2. Andrews, R. C.; Kirschler, L. H. (MSA Research Corp., Evans City, Pa.). 8 Dec 1969. Contract AT(11-1)-765. 1p. Dep. CFSTI.

Information is presented in a chart-type synopsis on stainless steel tensile properties at 73, 1200, and 1400°F in air as compared with atmospheres of He and environments of Na, Na-O, and Na-C. A use guide is included. (J.R.D.)

**14706** (TRG-Inf. Ser.-312(Suppl.2)) BIBLIOGRAPHY ON LIQUID METALS, 1966-1967. Fenney, S. H. (United Kingdom Atomic Energy Authority, Risley (England). Reactor Group). Sep 1969. 111p. Dep. CFSTI (U. S. Sales Only). UK 14s.

900 unclassified references to the literature on liquid metals, particularly Na and Na/K are presented. They cover material published in 1966 and 1967, and are a further continuation of TRG Information Series 312 (R), the 1st Supplement to which covered the years 1964 and 1965. (UK) (auth)

**14707** (WAPD-Trans-126) ROLE OF RARE EARTHS METALS IN THE PURIFICATION OF NIOBIUM. Trombe, Felix; Male, Germain. Translated for Bettis Atomic Power Lab., West Mifflin, Pa., from Rev. Int. Hautes Temp. Refract.; 5: 295-8 (1968). 8p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 23: 18235.

**14708** (WARD-3791-42) VANADIUM ALLOY CLADDING DEVELOPMENT. Quarterly Progress Report for the Period Ending September 30, 1969. (Westinghouse Electric Corp., Madison, Pa. Advanced Reactors Div.). Contract AT(30-1)-3791. 16p. Dep. CFSTI.

Activities in programs to develop and evaluate V-base alloys for LMFBR fuel cladding are summarized. Results of research on V reactivity with interstitial elements are presented along with results of corrosion testing of Vanstar alloys by flowing sodium and results of alloy-fuel compatibility testing. (J.R.D.)

**14709** (WCAP-7414) HEAVY SECTION FRACTION TOUGHNESS PROPERTIES OF A533 GRADE B CLASS I STEEL PLATE AND SUBMERGED ARC WELDMENT. Heavy Section Steel Tech-

nology Program Technical Report No. 6. Shabbits, W. O.; Pryle, W. H.; Wessel, E. T. (Westinghouse Electric Corp., Pittsburgh, Pa. PWR Systems Div.). Dec 1969. Contract W-7405-eng-26; Subcontract No. 3078. 65p. Dep. CFSTI.

For Oak Ridge National Lab., Tenn.

The fracture toughness ($K_{Ic}$), tensile, and Charpy V-notch properties generated for A533 Grade B Class 1 steel plate and submerged arc weldment material are presented. Also the equipment, techniques, and interpretation procedures used to obtain results from compact tension specimens up to 12 inches thick are described. The results indicated that the fracture toughness properties were highly temperature dependent with a rapid increase in toughness between 0°F and room temperature, and that the weldment material is comparable or of higher toughness than the base plate material. In the temperature range of practical interest, these high levels of toughness provide assurance of a high degree of fracture safety in heavy section welded structures. Included is a brief background on linear elastic fracture mechanics and a discussion on the significance of the data as related to the practical usefulness, applicability, and overall potential of the linear-elastic (plane-strain) fracture mechanics approach to the design against fracture. (auth)

**14710** LANTHANIDE SERIES AND YTTRIUM. Meckelburg, E. Metall, 23: 936-41(Sept. 1969). (In German).

The rare earths or lanthanides (Ln) consist of a group of 15 elements ranging from La (Z-57) to Lu (Z-71) and usually Y (Z-39) because of its common occurrence and great similarity. The atomic structure of Ln is formed by the successive build-up of the inner (4f) electron shell from 2 to 14. For this reason the Ln have a remarkable similarity of physical and chemical properties. Their reactivity makes separation in the metallic state impractical and, therefore, one uses for this purpose: electrolysis of fused chlorides; reduction of anhydrous chlorides with Na; electrolysis of $CeO_2$ in fused $CeF_3$; and thermal decomposition of amalgam. The technically important Mischmetall (mixed metal) is an alloy of the Ce-group of the Ln, consisting of La, Ce, Pr, Nd, Pm, and Sm. The most common production method of Ln metals consists in fusing of their water-free chlorides in cast iron pots or steel crucibles which serve as cathode and heating to about 750°C at which temperature the molten metals can be drained off. The raw metal is delivered in small ingots of ½ kg to the manufacturer for further processing. A universal production method of fairly pure Ln and Y metals (except Sm, Eu, Yb) is the Ca-reduction in fused $(NH_4)HF_2$ in a Ta crucible under an Ar atmosphere. Sm, Eu, and Yb are reduced with Ln or the Ce-group metals in a vacuum oven at 1400°C. Removal of accidental impurities is carried out by amalgamation and subsequent Hg distillation. The atomic, chemical, physical, thermal, elastic, magnetic, and electric properties of the individual Ln are given. About 25% of the Ln-chemicals are used for the manufacture of carbon arc lamps for search lights and other intensive light sources; about 25% are used in flints; 25% are used in the glass industry for coloring and optical lens grinding; the rest in the metallurgical industry for desulfuration of steel, increasing the durability of heating wires, and the oxidation resistance of Ni and other alloys at high temperatures. (F.J.W.)

**14711** INFLUENCE OF SMALL ADDITIONS OF YTTRIUM ON THE HIGH-TEMPERATURE RESISTANCE OF NIOBIUM. Bollenrath, F.; Happek, G. (Technische Hochschule, Aachen). Met. Ital.; 61: 473-80(Oct 1969). (In Italian).

It is known that an embrittlement of body-centered cubic lattice metals caused by interstitial elements such as H, C, N. O, can be prevented by additions of rare earths during the melting process. Owing to the great importance of high temperature plants in thermonuclear power stations and aerospace engineering techniques, the influence of yttrium additions on recrystallization and on the mechanical properties of four types of niobium with gradually increasing oxygen content (from 40 to 1,000 ppM) and an electric arc with non-consumable tungsten electrode in extremely pure argon atmosphere was investigated. Small castings were made with percentage additions of yttrium both low (0.01 to 0.04%) and slightly higher (0.1 to 1%). With greater additions of yttrium and high oxygen contents, $Y_2O_3$ segregations were found on the surface. The smaller additions of yttrium caused a recrystallization temperature increase from 1200 to over 1600°C as a result of a 60% cold work deformation. Greater additions lowered the recrystallization temperature: they produced a very fine grain and prevented grain growth even for 1 hour heating at 1600°C. To investigate the tensile properties, a specimen was cut from each casting, submitted to 60% coldwork deformation and then heated to 1440°C for one hour. From these specimens, 4 × 6 mm test pieces were obtained and submitted to compression tests in vacuum after which precise measurements of deformation were made. Small additions of yttrium resulted in considerable strength increase, particularly at high temperature. With higher yttrium additions, greater ductility and lower strength were observed while at high temperatures only a negligible strength diminution was noticed. The results indicate that favorable combinations of oxygen content in the niobium used in the casting process and yttrium additions (0.01 to 0.04%) lead to a fine dispersion of $Y_2O_3$—having a very high thermal stability—which increases the recrystallization temperature and high-temperature strength. With higher yttrium additions the $Y_2O_3$ particles coalesce in the molten metal and are dissolved, together with any incorporated elements, into the metallic yttrium. (auth)

**14712** INFLUENCE OF SMALL AMOUNTS OF BORON ON MORPHOLOGIC CHARACTERISTICS OF CAST IRON AND ITS MALLEABILIZATION PROCESS. Burdese, A.; Borlera, M. Lucco; Pradelli, G. (Politecnico, Turin). Met. Ital.; 61: 481-4(Oct 1969). (In Italian).

Experiments were performed in order to understand the behavior of boron especially when the nitrogen content of cast iron changes. As far as malleabilization processes were concerned, the presence of both elements was strongly accelerating and caused more nucleation centers to form even when boron nitride was not segregated. A theory is proposed for explaining the various effects of boron, founded on several experiments on cast irons containing different amounts of boron and nitrogen and tested at different steps of the malleabilization process. (auth)

**14713** ON THE PRE-PRECIPITATION PROCESS IN Al–4.4 PERCENT Zn–0.3 PERCENT Be ALLOY. Das, E. S. D.; Raman, K. S.; Vasu, K. I. (Indian Inst. of Science, Bangalore). Z. Metallk.; 61: 35-41(Jan 1970).

The aging kinetics of an Al–4.4% Zn alloy were studied after quenching from different temperatures and aging at different temperatures. After considering the different significant points on the aging curve and the errors involved, the apparent vacancy-formation energy of 0.70 eV was derived, giving a value of 0.06 eV for the v-Zn binding energy. Addition of 0.3% Be was found to slow down the rate of clustering considerably, although the zone-forming process was unaltered in the ternary alloy. Isochronal annealing experiments show that the zone-forming process and zone-reversion in the ternary alloy was very similar to that in the binary alloy. Be atoms seemed to influence the number of zones formed as witnessed from the strong influence of quenching temperature on the magnitude of peak height in the Be-containing alloy. Interpretation of the results of the ternary alloy yielded a value of 0.23 eV for the Be-v binding energy. The activation energy for migration of vacancies was about 0.42 ± 0.03 eV in both alloys, and was little influenced by quenching and aging temperatures. This led to the result: $E_D$ = 1.1 eV for solute diffusion in the alloy. (auth)

**14714** INVESTIGATIONS OF FRICTION-WELDED JOINTS IN ZIRCALOY-2. Eichhorn, F.; Schaefer, R. (Rheinisch-Westfaelische Technische Hochschule, Aachen). Kerntechnik; 11: 624-30(Nov 1969). (In German and English).

Following a review of the welding techniques tried out up to now for joining end plugs to fuel rod jackets, and of the relevant literature, an analysis is presented of the energy conversion phenomena occurring during the friction welding of round bars in Zircaloy 2. The results are given of mechanical strength tests, metallographic investigations, and hardness and corrosion tests of friction welded joints. In conclusion, a summary is given of favorable welding conditions and requirements are discussed for the development of suitable friction welding machines for joining fuel rod jackets and for improving the friction welding process. (auth)

**14715** STUDIES OF γ- AND γ′-SOLID SOLUTIONS OF Ni–Al–Nb–Mo SYSTEMS. Mints, R. S.; Toropov, V. M. Moscow Inst. of Metallurgy). Dokl. Akad. Nauk SSSR; 189: 130-3(1969). (In Russian).

The influence of molybdenum on the structure and properties of Ni–Al–Nb alloys in γ- and γ′-solid solutions was studied and the feasibility of increasing the level of high-temperature stability by alloying determined. Phase diagrams of quaternary Ni–Al–Nb–Mo and ternary Ni–Al–Nb alloys were constructed and analyzed at 1200°C and room temperature. (R.V.J.)

**14716** EFFECTS OF NIOBIUM ADDITIONS ON THE MACHINABILITY, MECHANICAL PROPERTIES, AND CORROSION BEHAVIOUR OF GREY AND MALLEABLE CAST IRONS. Sharan, R. (National Inst. of Foundry and Forge Tech., Ranchi, India); Sinha, D. N.; Gaindhar, J. L.; Maurya, J. C. Trans. Indian Inst. Metals; 22: No. 2, 47-9(Jun969).

Niobium additions in grey cast iron up to 0.25% showed improvements in machinability, hardness values, and shear and compressive strengths. The resistance to corrosion in hydrochloric acid

was also increased. In malleable cast iron the compressive strength improved by additions of niobium up to 0.5%, the shear strength and hardness values improved by additions up to 1%, the machinability improved by additions up to 1%, and the corrosion resistance in hydrochloric acid was increased by additions up to 2%. The results are critically discussed with reference to microstructures. (auth)

**14717** EFFECT OF SURFACE CHEMISTRY ON THE PHYSICAL PROPERTIES OF PRESSURE SINTERED BERYLLIUM METAL. Jagaciak, G. J.; Morana, S. J. (Beryllium Corp., Hazleton, Pa.). Powder Technol.; 3: 51-5(Oct 1969).

Processing variables in the commercial production of Be metal by the conventional pressure sintering technique were studied. Mechanical properties such as density, yield strength, ultimate tensile strength, elongation, and the precision elastic limit were evaluated and related to the characteristics of input powders and processing variables. Because Be metal in the as-cast condition had relatively poor mechanical properties, structural Be parts were produced commercially by powder metallurgy techniques. The process consisted of hot-pressing Be powder under vacuum at an applied unit pressure of about 1000 psi, and a temperature of about 1950°F. The particle size distribution and chemistry of the powder exerted a significant effect on the resulting physical properties, and recent findings indicated that relatively minor surface chemistry modifications of powders could become a significant variable controlling mechanical properties of pressure consolidated Be. Deposition of a uniformly thin layer of chromium on the surface of Be powder particles resulted in a pressure sintered product with room- and elevated-temperature properties higher than were previously observed in a hot pressed block. The alloy responded to heat treatment. (BBB)

**14718** CREEP DEFORMATION AND FATIGUE FAILURE OF STRUCTURAL MATERIALS. Darlaston, B. J. L. (Central Electricity Generating Board, Berkeley, Eng.). pp 95-100 of Safety and Failure of Components. London; Institution of Mechanical Engineers (1969).

From Conference on Safety and Failure of Components, Brighton, Eng. See CONF-690934.

In support of the vast amount of stress analysis work on components, considerable effort is required to provide suitable materials behavior models. Simple laboratory tests on uniaxially loaded specimens under constant temperature condition provide the bulk of data, but methods are required to translate these data to multiaxial conditions with nonuniform cyclic loading and cyclic temperature. Work carried out on Cr–Mo–V steels over a range of temperatures and loading conditions is described. This information is used to predict the deformation response in terms of loading conditions and the previous history of the material and to analyze the stress and strain cycles to predict failure. (UK)

**14719** COBALT-BASE ALLOYS IN AEROSPACE. Morral, F. R. (Battelle Memorial Inst., Columbus, Ohio). pp 111-21 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

The engineering capability of the industrial cobalt-base superalloys is examined. Developments in alloy design, as well as manufacturing techniques to extend usefulness of cobalt superalloys for temperature stability, corrosion resistance, creep, fatigue, and strength are reviewed as they apply to aircraft structures and parts. (auth)

**14720** MECHANICAL FASTENERS FOR HIGH TEMPERATURE STRUCTURE. Howell, James N. (Boeing Co., Seattle). pp 281-3 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

The selection of mechanical fastener materials for high temperature structure requires the consideration of a number of physical properties. The effect of these properties on the performance of mechanical fasteners in high temperature aircraft structure is discussed. Some materials suitable for such structural fastener applications are identified. (auth)

**14721** RECIPROCAL DIFFUSION IN Ti–V, Ti–Nb, Ti–Ta, AND Ti–Mo. Fedotov, S. G.; Chudinov, M. G.; Konstantinov, K. M. (Inst. of Metallurgy, Moscow). Fiz. Metal. Metalloved.; 27: 873-6(May 1969). (In Russian).

The distribution of elements in the diffusion layers was studied by x-ray spectral analysis. The coefficients of the reciprocal diffusion were calculated in the binary systems of titanium alloyed with molybdenum, niobium, tantalum, or vanadium. The relationship was established between the magnitude of the diffusion in the systems and elastic properties and the phase diagrams of these systems. (tr-auth)

**14722** AGING OF Fe–Mo AND Fe–Mo–Si ALLOYS. Kardonskii, V. M. (Central Scientific-Research Inst. of Ferrous Metallurgy, Moscow). Fiz. Metal. Metalloved.; 27: 890-4(May 1969). (In Russian).

Studies were made on the effects of heat treatment at 550 to 750°C on aging of annealed Fe–Mo alloys. The results showed that aging was proceeded by fine dispersion of the phase $Fe_2Mo$. The addition of Si to the alloy decreased the solubility of Mo in $\alpha$–Fe. (tr-auth)

**14723** EXPERIMENTAL STUDIES ON THE CORRESPONDENCY BETWEEN DEFECT AND NONDESTRUCTIVE TEST IMAGE AND THE EFFECT OF DEFECTS ON TENSILE STRENGTH IN STEEL-PLATES AND WELDS FOR A REACTOR PRESSURE-VESSEL. 3. Yosetsu Gijutsu; 17: No. 9, 77-89(Sep 1969). (In Japanese).

Tensile tests for wide joints at low temperature were performed on the variety of defects, as well as on the series with few defects to obtain basic information on the strength of welds. The base metal tested was ASTM A302B steel plate, and the welding rod was LBM-52. The nondestructive tests were made using radiation penetration and sonic and magnetic probes. The shape and dimension of the defects which appeared in the fractures broken by the defects were observed. The correlation between the length detected by x-ray penetration and that appearing on the fracture was generally good, but not as good using sonic probes for cracks. The correlation of defect depth was not good in the case of radiation penetration and sonic probing for cracks, insufficient weld penetration, and slag inclusion. In the radiation penetration, the correlation was not good for voids and cracks, but good for slag inclusion. The correlation was somewhat better in sonic probing. The correlation of defect height was not good in the case of the radiation penetration and sonic probing, for slag inclusion, insufficient weld penetration, and cracks. (NSA of Japan)

**14724** BERYLLIUM TECHNOLOGY. Lowe, J. N. (Atomic Weapons Research Establishment, Aldermaston, Eng.). J. Brit. Interplanet. Soc.; 22: 314-25(Oct 1969).

The current situation in beryllium research and development is described and the success in fabricating the material into a range of products is contrasted with the failure to alleviate the brittleness of the material. Acceptance of the fact that beryllium is an intractably brittle material now requires a reexamination of the basis of the engineering acceptance of brittle materials in structures, consequently attention is now directed to the work on fracture-toughness of beryllium to establish safe working stress levels for structurally loaded components. (auth) (UK)

**14725** PHYSICS OF STRENGTH AND PLASTICITY. Argon, Ali S. (ed.). Cambridge, Mass.; Massachusetts Institute of Technology Press (1969). 427p. $12.50.

The basic concepts in crystal plasticity and the mechanics of fracture of materials are given in 27 papers. The 17 papers in the physics of plasticity section contain information on individual dislocations and basic deformation mechanisms and hardening mechanisms and dislocation dynamics. The 10 papers in the physics of strength section concentrate on cracks and fracture and geology. (J.C.W.)

**14726** EFFECTS OF TANTALUM CARBIDE ON STRENGTH AND DEFORMATION OF WC–TiC–Co UNDER COMPRESSION. Tumanov, V. I.; Kreimer, G. S.; Bragilevskii, V. L.; Bogino, E. M. (All-Union Scientific-Research Inst. of Hard Alloys, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1938-42 (Nov 1969). (In Russian).

The stability and deformation of WC–TiC–Co during static and shock tests were studied with varying additions of 0 to 48 mole percent TaC. The results showed that strength and deformation during compression varied linearly in relation to the concentration of TaC. The addition of 7.5 mole percent TaC reduced strength, static and dynamic fluidity, and deformation during compression. Additions of 48 mole percent TaC caused reverse effects. The maximum plastic deformation of alloys during compression increased linearly due to the effect of the chemical composition of the cobalt solid solution. (tr-auth)

**14727** ESTIMATION OF CERTAIN PHYSICAL PROPERTIES OF LIQUID FRANCIUM. Os'minin, Yu. P. (Moscow Aviation Inst.). Zh. Fiz. Khim.; 43: 2610-11(Oct 1969). (In Russian).

The method of thermodynamic similarity was used to evaluate the heat of melting, density, heat capacity, viscosity, and surface tension of liquid $^{223}Fr$ in the temperature range from the melting point to 700°C. (tr-auth)

**14728** THERMODYNAMICS OF SOLUTIONS OF YTTRIUM, CERIUM, AND URANIUM IN LIQUID MAGNESIUM. Bayanov, A. P. (Siberian Metallurgical Inst., Novokuznetsk, USSR). Zh. Fiz. Khim.; 43: 2231-3(Sep 1969). (In Russian).

Values of the activity coefficients and the excess partial free energies of yttrium, cerium, and uranium in liquid magnesium at 1073°K were calculated. (tr-auth)

**14729** EFFECT OF PRESSURE ON THE CURIE TEMPERATURE OF $ZrZn_2$. Wayne, R. C.; Edwards, L. R. (Sandia Labs., Albuquerque, N. Mex.). Phys. Rev.; 188: 1042-4(10 Dec 1969).

The initial pressure derivative of the Curie temperature of $ZrZn_2$ has been measured under hydrostatic conditions, yielding a value of $-1.95 \pm 0.1$°K kbar$^{-1}$ for a sample with a Curie temperature of $21.5 \pm 0.5$°K. This is in good agreement with the values of $-1.8$ and $-2.4$°K kbar$^{-1}$ predicted by Wohlfarth using the model of a very weak itinerant ferromagnet and two different methods of calculation. The present measurement allows an estimate of the effective degeneracy temperature for $ZrZn_2$ of 300°K and an estimate for the initial differential susceptibility of $6.2 \times 10^{-5}$ emu g$^{-1}$ Oe$^{-1}$. (auth)

**14730** INTERACTION OF LANTHANUM HEXABORIDE WITH GRAPHITE, MOLYBDENUM, AND TANTALUM. Gert, L. M.; Babad-Zakhryapin, A. A.; Minashkin, V. I. Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 2198-9(Dec 1969). (In Russian).

Studies were made on the interaction of lanthanum hexaboride powders with graphite, molybdenum, and tantalum at 1200 to 2000°C. It was found that during the interaction of lanthanum borides with tantalum and tungsten, a boride surface was formed on the tantalum and tungsten, and metallic lanthanum was formed. At 1900 to 2000°C, the interaction of boron with carbon formed the eutectic B + $B_4C$. It was found that $LaB_6$ has a weaker reaction with tantalum than with molybdenum. No reaction was observed with graphite and lanthanum hexaboride at 1500°C. The characteristics of lanthanum boride reactions with molybdenum and tantalum are tabulated. (R.V.J.)

**14731** MICROHARDNESS OF CARBIDES OF CERTAIN TRANSITIONAL METALS. Bazhenova, L. N.; Ivan'ko, A. A. (Kiev Polytechnic Inst.). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 2071-4(Dec 1969). (In Russian).

The results of the microhardness of TiC, ZrC, HfC, VC, NbC, TaC, $Cr_3C_2$, $Mo_2C$, and WC are given. An attempt was made to correlate the microhardness to the peculiarities of the electron structure of these compounds. Data are tabulated. (tr-auth)

**14732** AN INVESTIGATION OF THE FACTORS AFFECTING THE FRACTURE CHARACTERISTICS OF CRACKED TUNGSTEN CRYSTALS. Key II, Paul Leland. Berkeley, Calif.; Univ. of California (1969). 121p.

Thesis.

The fracture of tungsten single crystals containing cracks of a known size and shape was investigated both analytically and experimentally. Analytically, the methods of linear elastic fracture mechanics were applied to establish several possible criteria for the fracture of cracked crystals including both critical local stress and critical strain energy release rate criteria. Experimentally, small cracks (about 150 $\mu$ deep) were introduced into tungsten single crystals of various crystallographic orientations by a spark discharge technique. The tensile fracture behavior of these cracked crystals was then evaluated at room temperature for both unannealed crystals and for crystals annealed in the range 1200 to 2400°C. The fracture of many of the cracked crystals required a sharp crack to be nucleated from the spark induced crack prior to fracture. The fracture behavior of these crystals was controlled by the crack nucleation processes. For other crystals, the spark crack could be directly propagated and a crack propagation criterion based on either a local or total strain energy release rate appeared to best describe the data. The fracture behavior of cracked tungsten crystals was significantly affected by annealing. At room temperature, the fracture surface energy decreased, then increased as the annealing temperature was increased and the opposite effect was observed at liquid nitrogen temperature. (Diss. Abstr. Int., B)

**14733** STRESS RELAXATION STUDY OF MONOCRYSTALS OF SOME BCC METALS AND ALLOYS. Coplin, Donald Herbert. Houston, Tex.; Rice Univ. (1969). 174p.

Thesis.

A comprehensive study of the effects of strain, temperature, and dilute alloy concentration was made on tantalum and molybdenum single crystals. Stress relaxation experiments were used to evaluate the thermal activation parameters. The tests were run at 77 to 373°K and at prestrains between $10^{-4}$ and $4 \times 10^{-2}$. The solute used was rhenium in atomic concentrations of less than 10%. The experimental procedure consisted of performing stress relaxations on identically oriented single crystals by plastically deforming at low strain rates, then stopping the cross-head and measuring the time dependence of the stress. Each crystal was alternately strained and allowed to relax. The data were analyzed by fitting the relaxing stress, $\tau$, to the time, t, equation $\tau = A - [(kT/V) \ln (t + C)]$ where A and C are constants and V is the activation volume. The other terms have the usual meanings. This equation was derived from the basic strain rate equation for a single thermally activated process. The activation energy was found by using the following relation $Q/V = A - \tau_\mu - kT/V \ln (MkT/V\dot{\epsilon}_0)$ where Q is the activation energy, $\tau_\mu$ is the structural stress, M is the reciprocal of the machine and sample modulus, and $\dot{\epsilon}_0$ is the preexponential in the strain rate equation. The activation energies were found to be the same for all the metals and alloys tested. The addition of rhenium caused the activation volumes to increase. The temperature dependence of the flow stress decreased with rhenium content in the tantalum alloys. The effective structural stress was found to have nearly the same temperature dependence as the flow stress. The results are discussed in the light of the most recent theories for flow in body centered cubic crystals. The results are not in complete agreement with the predictions by Escaig on the cross-slip of dissociated screw dislocations, or with the Peirels mechanism by Dorn. Significant differences are shown in the effective stress and activation energy parameters. (Diss. Abstr. Int., B)

**14734** HIGH-FIELD GALVANOMAGNETIC PROPERTIES OF INDIUM. Garland, James C.; Bowers, R. (Cornell Univ., Ithaca, N. Y.). Phys. Rev.; 188: 1121-9(15 Dec 1969).

Measurements are reported of the high-field magnetoresistance and Hall effect of both single-crystal and polycrystalline indium. Although the magnetoresistance exhibited no pronounced crystal anisotropy, substantial deviations from Kohler's rule were observed. It is found that both the longitudinal and transverse magnetoresistance increase linearly in high-purity specimens but not in impure material. Other deviations from Kohler's rule are attributed to small-angle electron–phonon scattering. The Hall coefficient of indium was found to decrease slightly with increasing magnetic field. Measurements were made using dc techniques as well as the standing-wave helicon method; in addition, solutions of the helicon wave equation for a finite cylinder transverse to the magnetic field are considered. (auth)

**14735** SEEBECK COEFFICIENTS OF LUTETIUM SINGLE CRYSTALS. Edwards, L. R.; Schaefer, J.; Legvold, S. (Ames Lab., Iowa). Phys. Rev.; 188: 1173-4(15 Dec 1969).

The Seebeck coefficients of lutetium were measured along the $[10\bar{1}0]$ (b axis) and [0001] (c axis) crystallographic directions as a function of temperature from 8 to 300°K. These results are compared with the single-crystal Seebeck coefficients of yttrium and discussed in terms of the Fermi surface. (auth)

**14736** THERMODYNAMICS OF ALLOYS OF RARE EARTH ELEMENTS WITH VARIOUS METALS. Burylev, B. P.; Vasil'ev, V. V. (Siberian Metallurgical Inst., Novokuznetsk, USSR). Zh. Fiz. Khim.; 43: 2771-5(Nov 1969). (In Russian).

Exchange energies of more than 90 elements of the periodic system with scandium, yttrium, and lanthanum were calculated. A relation was obtained that permitted general conclusions to be made on the character of the reaction of rare earth elements with other metals. The forms of phase diagrams were predicted. Thermodynamic properties of many rare earth alloys were calculated. The relation of reaction constants to composition and temperature was noted. (tr-auth)

**14737** THERMODYNAMICS OF THE LANTHANUM–ZINC SYSTEM. Mullayanov, R. Kh.; Lebedev, V. A.; Kanashin, Yu. P.; Nichkov, I. F.; Raspopin, S. P. Zh. Fiz. Khim.; 43: 2776-9 (Nov 1969). (In Russian).

The electromotive force of galvanic elements was measured at 715 to 1022°K both in the region of La–Zn homogeneous solution and in the region of saturated solution–intermetallic compound. Partial molar and integral thermodynamic values were calculated for characterizing the state of La in Zn solutions. The temperature dependence of the coefficient of activity of La and the magnitude of its solubility in molten Zn were established. (tr-auth)

**14738** STRENGTH OF NEAR-PERFECT SINGLE CRYSTALS OF CADMIUM. Crump III, J. C.; Mitchell, J. W. (Univ. of Virginia, Charlottesville). J. Appl. Phys.; 41: 717-22(Feb 1970).

The ultimate strength of thin single crystals of cadmium has been measured. The crystals were initially completely free from dislocations and other imperfections as established by observations with the electron microscope. They were grown from the vapor in an atmosphere of argon and had surfaces parallel to $\{0001\}$ and $\{01\bar{1}0\}$ planes, $[\bar{2}110]$ axes, and uniform rectangular cross sections. The crystals were strained in the electron mi-

croscope with a pneumatic tensile device, and the maximum elastic strain which they would sustain was determined directly from measurements of diffraction patterns. The near-perfect crystals failed at measured elastic strains between 3.8% and 4.5% along the [$\bar{2}$110] direction. The corresponding normal stress was also measured directly with the tensile device. When the elastic strain along the [$\bar{2}$110] axis of tension is 4%, the resolved shear stress on the glide systems which could be activated varies between G/11 and G/15, where G is the relevant shear modulus. This is within the range of estimated theoretical maximum strengths of crystals for deformation by a homogeneous shear process. (auth)

**14739** STRENGTH LOSS ON ANNEALING OF FORGED METALLOCERAMIC RHENIUM. Zakharov, A. M.; Pshokin, V. P.; Novikov, I. I.; Melikman, A. N.; Pavlova, E. I. Izv. Vyssh. Ucheb. Zaved., Tsvet. Met.; No. 4, 120-3(1969). (In Russian).

The strength loss on annealing of two samples of cold-deformed metalloceramic rhenium was studied. The temperature of recrystallization of this rhenium was 1000 to 1050°C. Annealing at 1300°C for 10 min was necessary for complete recrystallization. (M.C.G.)

**14740** SOLUBILITIES OF BISMUTH AND TELLURIUM IN LIQUID SODIUM. Walker, R. A.; Pratt, J. N. (Univ. of Birmingham, Eng.). J. Nucl. Mater.; 34: 165-73(Feb 1970).

The solubilities of bismuth and tellurium in high-purity, liquid sodium were measured at 252 to 563°C and 222 to 572°C, respectively, by an equilibration and sampling technique: the solubility of bismuth increased from approximately 0.001 to 1.0 at.% and that of tellurium from 0.03 to 0.26 at.%. X-ray diffraction analyses showed that the compounds $Na_3Bi$ and $Na_2Te$ were in equilibrium with the liquid sodium during the respective solubility determinations. For the tellurium data, the variation of solubility with absolute temperature T was equated to the expression log (at.% Te) = $0.7501 - 1281.3/T$. The bismuth solubility results were equated, together with other recently reported data, to the expression log (at.% Bi) = $7.7169 - 8.1316 \pm 10^3/T + 1.3774 \pm 10^6/T^2$. The partial molal heats of solution in liquid sodium of solid bismuth and solid tellurium were determined respectively to be $-37.8 \pm 5.0$ kcal/mole and $-70.4 \pm 10.0$ kcal/mole at infinite dilution. (auth)

**14741** INFLUENCE OF OXYGEN PRESSURE ON THE MECHANICAL PROPERTIES IN AIR AND HYDROGEN OF THE ALLOY Nb-5Mo. Vercaemer, Claude; Geschier, Roland; Guille, Jean; Clauss, Auguste (Univ., Strasbourg). Compt. Rend., Ser. C; 269: 1494-7(15 Dec 1969). (In French).

The influence of oxygen pressure on the mechanical properties of a Nb–Mo alloy at ambient temperature was studied. Considerable brittleness was evident when the experiments were carried out in an atmosphere of hydrogen. The presence of water vapor in the hydrogen decreased this brittleness. (tr-auth)

**14742** SLIPPING AND GAMMA INTERGRANULAR CRACKING IN THE ALLOYS $UMo_{1.1}$ AND $UMo_{1.1}Al_{0.05}Sn_{0.05}$. Khan, Tasadduq; Brun, Gilbert; Decours, Jacques (CEN de Saclay, Gif-sur-Yvette, France). Compt. Rend., Ser. C; 269: 1490-3 (15 Dec 1969). (In French).

The study of the tensile properties between 450 and 630°C of the alloys $UMo_{1.1}$ and $UMo_{1.1}Al_{0.05}Sn_{0.05}$ with large gamma grains (1,000 to 1,500 $\mu$) and cooled down from the gamma region at rates between 50 and 150°C/min made it possible to show the relation between the minimum ductility of these alloys at 590°C and the gamma intergranular cracking. (tr-auth)

**14743** DISINTEGRATION OF SUPERSATURATED SOLID SOLUTIONS OF Al–W ALLOYS. Kolomoitseva, L. F.; Varich, N. I.; Burov, L. M. (Dnepropetrovsk State Univ., USSR). Fiz. Metal. Metalloved.; 28: 782-6(Nov 1969). (In Russian).

The decomposition of highly supersaturated solid solutions in Al–W alloys, produced during rapid cooling of liquid solutions, $\sim 10^{6}$°/sec, from the annealing temperatures, was studied. The supersaturated solid solution of Al–W was stable at 600°C. The disintegration started with annealing at 600 to 650°C and increased with a further rise of temperature. An abnormal increase in electric resistance related to the zonal aging was also observed. (R.V.J.)

**14744** INFLUENCE OF TEMPERATURE AND RATE OF DEFORMATION ON THE FLOW INTENSITY OF LANTHANUM. Solenov, V. M.; Sokolov, L. D.; Gladkikh, A. N. (Gorky Polytechnic Inst., USSR). Fiz. Metal. Metalloved.; 28: 915-20(Nov 1969). (In Russian).

The effects of temperature and the rate of deformation on lanthanum flow were studied. A relationship was established between the rate index n for a homologous temperature series and temperature coefficient B from the rate and degree of deformation. Diagrams showed that the rate of flow and deformation, among other factors, depend on the lattice of the material. (R.V.J.)

**14745** DIFFUSION IN In–Hg AMALGAMS. Nanda, A. K.; Shuck, Frank O. (Ames Lab., Iowa). Met. Trans.; 1: 353-6(Feb 1970).

Measurements of the diffusion coefficient in In–Hg amalgams of 3.5 to 20.0 at.% In were made at 20 to 40°C using a modified diaphragm cell. In this range the data may be represented by the relation $D = 2.71 \times 10^{-3} (\exp [-3260/RT])(1 + 2.66N)$. The high value of the radius of the diffusing species obtained from the Stokes-Einstein Equation and the high activation energy obtained tend to indicate that the diffusion involves a species more complex than the indium atom or ion. (auth)

**14746** TRANSMISSION ELECTRON MICROSCOPY OF Cu–Zr–Cr ALLOY. Henmi, Zenzo; Nagai, Takeshi (Fujitsu Labs. Ltd., Kawasaki, Japan). Trans. Jap. Inst. Metals; 10: 305-13(Sep 1969).

Cu–Zr–Cr alloy does not soften by prolonged high-temperature heating and its electrical conductivity ranges between 75 and 80% IACS, so that the alloy is extensively used as electrodes for diverse welding purposes. A study of the origin of high softening temperature in this alloy has been made using a transmission electron microscope. The results show that the presence of Cr and Zr atoms in copper solid solution retard the recovery, recrystallization and precipitation. The recovery and recrystallization, which result from the dislocation climb and glide, may be retarded by locking of dislocations due to the presence of Cr or Zr atoms or both, and the reduction in self-diffusivity of the Cu in copper solid solution due to the presence of Cr or Zr, or both. From the retardation of recovery and recrystallization in the ternary alloy, it can also be predicted that the diffusion coefficient of Cr or Zr, or both, is low. Aging at 400°C for 1 hr after roll-flattening hardens the Cu–Zr–Cr alloy. However, transmission electron microscopy does not reveal the origin of the hardening. This may correspond to the phenomena known as low temperature anneal hardening. (auth)

**14747** PRECIPITATION OF PLUTONIUM COMPOUNDS IN IRRADIATED MAGNESIUM ALLOY FUEL ELEMENT CANS. Pearce, J. H. (United Kingdom Atomic Energy Authority, Seascale, Eng.). J. Nucl. Mater.; 34: 1-10(Jan 1970).

Thin foils which contain the inner surface of irradiated fuel element cans were cut with an ultramicrotome. Transmission electron microscopy revealed numerous fine precipitates within 25 $\mu$m of the inner surface of irradiated AL80 (Mg/0.8 wt % Al) cans but very few in irradiated ZR55 (Mg/0.5 wt % Zr) cans. Alpha-counting of foils showed that plutonium had penetrated into the can wall to differing extents in the two materials; it was confined to the region containing the precipitate in an AL80 can irradiated at 405°C but had diffused about 1 mm into a ZR55 can irradiated at 300°C for half the time. Some of the precipitate particles in AL80 were identified as $PuAl_3$ by electron diffraction. It is concluded that the precipitation of plutonium–aluminum compounds at the inner surface prevents plutonium diffusing through the can wall of AL80 clad fuel elements during irradiation. (auth)

**14748** MEASUREMENT OF THE RATE OF DIFFUSION OF PLUTONIUM IN IRRADIATED Mg/0.5 WT. PERCENT Zr FUEL ELEMENT CANS BY CONTROLLED ABRASION AND ALPHA-COUNTING. Hyam, E. D.; Sumerling, R. (United Kingdom Atomic Energy Authority, Seascale, Eng.). J. Nucl. Mater.; 34: 21-33(Jan 1970).

Previous work has shown that plutonium can permeate the matrix of a Mg/0.5 wt % Zr (Magnox ZR55) fuel element can irradiated in contact with uranium and that the concentrations produced at an irradiation level of 0.17 at.% burn-up range from $\approx 1 \times 10^{-3}$ at.% near the can inner surface to $\approx 1 \times 10^{-5}$ at.% near the can outer surface. By alpha-counting either material removed by controlled abrasion or the abraded surface itself, it was established that this solute plutonium segregates to a free surface by diffusion from the adjacent matrix. The amount accummulating at a surface as a result of a given annealing treatment was proportional to the initial concentration of plutonium in the underlying layers. A study of the rates of accumulation of plutonium at a surface at different temperatures indicated that the activation energy of the diffusion process was 31 kcal/mole. Measurement of the concentration gradients developed in the matrix, adjacent to a surface at which plutonium was segregating, enabled values of the diffusion coefficient D to be obtained for temperatures of 400 and 450°C. The value of $D_0$ derived from the experimental results is in the range 0.095 to 0.225 $cm^2/s$ (mean value 0.15 $cm^2/s$). (auth)

**14749** CHEMICAL DIFFUSION AND THE KIRKENDALL EFFECT IN THE CUBIC CENTERED PHASE OF THE PLUTONIUM–ZIRCONIUM SYSTEM. Remy, C.; Dupuy, M.; Calais, D. (CEN, Fontenay-aus-Roses, France). J. Nucl. Mater.; 34: 46-58(Jan 1970). (In French).

Solute diffusion and the Kirkendall effect were studied in the $\epsilon\beta$ body centered cubic phase of the Pu–Zr system, with the technique of welded couples. The concentration/penetration curves obtained by electron probe microanalysis were interpreted by the methods of Hall and Matano. The chemical diffusion coefficients measured from 650 to 900°C increased with plutonium concentration and obeyed Arrhenius' law. Activation energies ranged from 44 to 18 kcal/mole as the concentration ranged from 20 to 60 at.% plutonium. The existence of a Kirkendall effect in the Pu–Zr system was shown by the displacement of inert wires, initially placed in the welding plane, towards the element which diffused more rapidly. Each of the elements which constituted the diffusion couple was therefore characterized by its own intrinsic diffusion coefficient $D_{Pu}$ or $D_{Zr}$. The variation of the intrinsic diffusion coefficients, of the flux $J_{Pu}$ and $J_{Zr}$ of the two species, and of the mean lattice velocity v as a function of concentration, was studied by the technique of incremental couples. These couples were made from a pellet of pure zirconium attached to a pellet of Pu–Zr alloy of different compositions in the various samples. Two methods were used to measure $D_{Pu}$ and $D_{Zr}$. The first made use of the two equations of Darken; and the second method used an additional relationship by Heumann. In the range of concentrations studied (15 to 16 at.% plutonium) plutonium diffused the more rapidly. The ratio $D_{Pu}/D_{Zr}$ increased with plutonium concentration, and ranged from 1.5 to 6. The flux $J_{Pu}$ and the mean atomic velocity had their largest value near the Kirkendall plane, while on the other hand $J_{Pu}$ and $J_{Zr}$ did not appear to reach extreme values simultaneously. This study has shown that the equations of Darken and Heumann were well able to interpret the studied phenomenon within the limits of experimental errors. On the other hand, the Kirkendall effect observed in the Pu–Zr system showed in an unambiguous manner that diffusion in this system took place by a mechanism which involved the nonconservative migration of defects (vacancies or interstitials). (G.M.C.)

**14750** STUDY OF THE DEFECTS PRODUCED IN BERYLLIUM BY HAMMER-HARDENING AT LOW TEMPERATURE. Nicoud, J. C.; Delaplace, J. (CEN, Grenoble, France). J. Nucl. Mater.; 34: 70-80(Jan 1970). (In French).

The electrical resistivity of beryllium wires deformed in tension at the temperature of liquid nitrogen increased linearly with deformation for deformations not exceeding 0.5%. 60% of the initial resistivity excess was recovered at room temperature. The recovery developed in a continuous phase from 77 to 500°K. Two principal stages of recovery were observed, one near 190°K and one near 290°K, followed by a region of substantial recovery which continued up to 500°K. Measurements of internal friction at low frequency made between 200 and 500°C on beryllium wires deformed at low temperature showed a substantial increase of modulus between 100 and 300°C and also an irregular peak of internal friction of which the maximum was situated near 200°C. The recovery of electrical resistivity below room temperature is explained by the disappearance of point defects created by deformation. The recovery of electrical resistivity, the increase of modulus, and the peak of internal friction observed above room temperature could be due to a rearrangement of the dislocation network generated by deformation, with diminution of their density. Electron-micrographical observations confirm this interpretation. (auth)

**14751** RECRYSTALLIZATION OF ALPHA-PLUTONIUM BY EXTRUSION. Merz, M. D. (Battelle-Northwest, Richland, Wash.). Contract AT(45-1)-1830. J. Nucl. Mater.; 34: 108-10(Jan 1970).

Alpha-plutonium of unusually uniform fine grain size and high density was fabricated by an extrusion and concurrent recrystallization method. (G.M.C.)

**14752** SOLID SOLUBILITY OF ALUMINUM IN α-ZIRCONIUM. Tiwari, S. N.; Tangri, K. (Univ. of Manitoba, Winnipeg, Can.). J. Nucl. Mater.; 34: 92-6(Jan. 1970).

In the present investigation the x-ray parametric method was used to determine the solvus curve in the zirconium rich region of the Zr–Al system, down to temperatures lower than 700°C. The lattice parameter a of the α-zirconium decreased linearly with the aluminum content x in the atomic percent according to the relation $a = 3.2332 - 0.0044x$, while the parameter c changed irregularly. The solid solubility limits determined in the earlier investigation are lower than those found in the present work. (auth)

**14753** CARBON CHEMISORPTION IN ZIRCONIUM SURFACE. Ailloud, Pierre; Touboul, Jean-Paul; Langeron, Jean-Paul (CNRS, Vitry-sur-Seine, France). Compt. Rend., Ser. C; 270: 184-6(12 Jan 1970). (In French).

The study of carbon chemisorption in a zirconium surface shows that the thermal stability of the superficial striation is due to carbon. A proportional relation between the mass concentration and the chemisorbed layer characterized by the ratio between the number of occupied sites and the number of possible sites was found. (auth) (France)

**14754** MECHANICAL BEHAVIOR OF POLYCRYSTALLINE $HoZn_2$. Michel, David J.; Ryba, Earle (Pennsylvania State Univ., University Park). Met. Trans.; 1: 544-5(Feb 1970).

Results of compression tests on polycrystalline $HoZn_2$ are reported. Data are tabulated on failure stresses and specimen density. The specimens were observed to fail explosively primarily along the direction of loading. (J.R.D.)

**14755** CREEP OF INTERNALLY NITRIDED MOLYBDENUM-BASED ALLOY IN A NITROGEN ENVIRONMENT. Kane, James S. (Univ. of California, Livermore). Met. Trans.; 1: 548-9(Feb 1970).

Results of investigations of internal nitriding effects on creep and maintenance of strength in the nitride phase in TZM are reported. Measurement results are presented graphically for specimens load stressed at 4100 psi at 1450°C as creep strain percent in relation to time. A significant increase in high-temperature creep resistance was found in TZM first internally nitrided then tested in nitrogen. (J.R.D.)

**14756** THE MECHANISM OF CREEP IN GAMMA PRIME PRECIPITATION-HARDENED NICKEL-BASE ALLOYS AT INTERMEDIATE TEMPERATURES. Leverant, Gerald R.; Kear, Bernard H. (Pratt and Whitney Aircraft, Middletown, Conn.). Met. Trans.; 1: 491-8(Feb 1970).

The creep deformation of Mar-M200 single crystals of various orientations has been studied at a temperature of 1400°F. It was found by a combination of transmission microscopy and analysis of lattice rotations that shear of the $\gamma$-$\gamma'$ structure occurs by the glide of loosely coupled intrinsic/extrinsic fault pairs with a net Burgers vector of a$\langle 112 \rangle$. The orientation dependencies of both the rate and extent of primary creep are correlated with the Schmid factors and multiplicity of slip for $\{111\}\langle 112 \rangle$ systems. It is also shown that strain hardening due to intersecting slip is necessary to obtain the transition from primary to steady-state creep. In addition, it was found that the deformation mode is a function of strain rate at 1400°F. In contrast to the observed glide mechanism during creep, tensile deformation occurs by the shear of the $\gamma$ and $\gamma'$ phases by a/2$\langle 110 \rangle$ superlattice pairs. (auth)

**14757** THE RESISTIVE CRITICAL FIELD OF NIOBIUM (COLUMBIUM) WIRE. Pearson, J. R.; Rose, R. M. (Massachusetts Inst. of Tech., Cambridge). Met. Trans.; 1: 377-82(Feb 1970).

The transverse and longitudinal resistive critical fields of niobium wires with drawing strains up to eleven were measured. The magnitude and anisotropy of the resistive critical field can both be much greater than the bulk Ginzburg–Landau parameters indicate, even if internal surface nucleation of superconductivity is assumed. It is suggested that these effects are due to superconductivity in the dislocation cell walls created by drawing or swaging. A simple model for this effect is offered, and various experiments which test this model are discussed. (auth)

**14758** FIZIKO-KHIMICHESKIE ISSLEDOVANIYA ZHAROPROCHNYKH SPLAVOV. (Physico-Chemical Studies of Heat-Resistant Alloys). Ageev, N. V. (ed.). Moscow; Izdatel'stvo Nauka (1968). 176p.

Information on the chemical and physical properties of heat-resisting alloys is presented in fifteen sections. A separate abstract was prepared for six sections. The remaining nine sections contain information not within scope of NSA. (R.C.K.)

*For abstracts of individual sections see: 14759–14764.*

**14759** PHYSICOCHEMICAL PROPERTIES OF REFRACTORY ALLOYS. Samarin, A. M.; Averin, V. V. pp 5-18 of Fiziko-Khimicheskie Issledovaniya Zharoprochnykh Splavov. /Ageev, N. V. (ed.). Moscow; Izdatel'stvo Nauka (1968). (In Russian).

The thermodynamic conditions of dissolution of O and N in refractory alloys of Fe–Cr and Ni–Cr were studied. Diagrams on the oxidation of Al, Si, and Ti in complex-alloyed alloys are given. Results were obtained on the effects of chromium on silicon and titanium in cobalt-base, iron-base, and nickel-base alloys. The results of the effects of vacuum on the concentration of oxygen in metals are also given. A comparison was made of the results with Ni–$ThO_2$. (tr-auth)

**14760** HEAT-RESISTING MATERIALS BASED ON REFRACTORY METALS. Savitskii, E. M. pp 19-31 of Fiziko-Khimicheskie Issledovaniya Zharoprochnykh Splavov. /Ageev, N. V. (ed.). Moscow; Izdatel'stvo Nauka (1968). (In Russian).

Heat-resisting alloys for prolonged high-temperature operation, (1000°C or above) were prepared from refractory metals and al-

loys of IV A and VII A Groups of the periodic table. Progress is reported on present-day chemical techniques for the production of pure substances, vacuum metallurgy and treatment of refractory metallic materials, and physicochemical and metallographic methods of investigating the structure and properties of metals and alloys at high temperature in vacuum. Data are given on the theory of metals and alloys including electronic state, phase diagrams and composition-property diagrams, mechanisms of alloying and refining action, effects of interstitial impurities and defects on the temperature for the transition to a brittle state, and structure and properties of high-purity single crystals of refractory metals. Recent data on the mechanical properties of structural Nb alloys at high temperatures are given. (JPRS) (TSS)

**14761** MECHANICAL PROPERTIES OF REFRACTORY METALS. Gulyaev, A. P.; Morgunova, N. N.; Klypin, B. A. pp 32-9 of Fiziko-Khimicheskie Issledovaniya Zharoprochnykh Splavov. /Ageev, N. V. (ed.). Moscow; Izdatel'stvo Nauka (1968). (In Russian).

The effects of temperature and the principal metallurgical and and technological factors (impurity content, structural state, and deformation rate) on the mechanical properties of refractory metals of groups VA and VIA were studied. The temperature dependences of the mechanical properties and the influence of these factors were of a diverse character in the range of low (up to ~0.2 $T_m$), medium (0.2 to 0.5 $T_m$), and high (above ~0.5 $T_m$) homologous temperatures. Some regularities were noted in changes in the plastic-to-brittle transition temperature for refractory metals in relation to the enumerated factors. It was found that metals were characterized by a tendency towards intergranular fracture (hot brittleness). It was found that the plasticity level in the hot-brittleness temperature range and the limits of this range depend on the impurity content and the deformation rate. (JPRS)

**14762** ELECTRONIC THEORY OF HEAT-RESISTING ALLOYS BASED ON REFRACTORY METALS WITH A BCC LATTICE. Grigorovich, V. K. pp 40-56 of Fiziko-Khimicheskie Issledovaniya Zharoprochnykh Splavov. /Ageev, N. V. (ed.). Moscow; Izdatel'stvo Nauka (1968). (In Russian).

The structures and properties of refractory metals of groups IV to VI are explained by the application of the valence bond theory to the electrons of the outer $p^6$ shells of the metal ions. These electrons are regarded as collective and interact with the periodic potential field of the lattice. The lattice energy is determined with allowance for overlap and volume interaction of the outer shells of the ions. An increase in the electron concentration of a bcc solid solution as a result of alloying a lower-valent metal by a higher-valent and refractory metal is accompanied by an increase in lattice energy and a rise in the melting point and heat-resistance. Such a hardening mechanism is of little effect for highest-valence metals (Nb, Ta, Mo, W), inasmuch as the alloying elements reduce the electron concentration and melting point of the alloy. It is more effective to increase heat resistance by precipitation hardening of molybdenum, tungsten, niobium, and tantalum with refractory carbides, nitrides, and oxides. In the process carbon, nitrogen, and oxygen, which form interstitial solid solutions in bcc metals, are converted to a bonded state by means of small additions of titanium, zirconium, and hafnium. The electronic structure of ions of light elements in interstitial solid solutions and in refractory compounds was considered. It was found that the dissolved atoms represent cations, whereas in the compounds they form covalent bonds. There is a discussion of the possibilities of replacement of the atoms of metallic and nonmetallic elements in refractory compounds, resulting in the formation of stable alloyed carbides, nitrides, and oxides. (JPRS)

**14763** HOMOLOGOUS LAW OF DIFFUSION AND THE ALLOYING OF REFRACTORY METALS. Prokoshkin, D. A.; Vasil'eva, E. V. pp 96-106 of Fiziko-Khimicheskie Issledovaniya Zharoprochnykh Splavov. /Ageev, N. V. (ed.). Moscow; Izdatel'stvo Nauka (1968). (In Russian).

Literature data were analyzed concerning the constants of self-diffusion of 14 cubic and hexagonal metals in a wide range of temperatures. It was found that at similar temperatures, the constants of self-diffusion of the metals had similar values. X-ray spectral analysis was used to study the reciprocal diffusion in the vapor of elements in Groups IV, V, and VI. Investigations of high temperature creep of alloys of Nb with Ti, Zr, V, Mo, Ta, and W showed that the solid solution creep resistance was a function of the melting point of the alloying element. (tr-auth)

**14764** QUESTIONS IN THE THEORY AND TECHNIQUE OF WELDING NIOBIUM- AND NICKEL-BASE HEAT-RESISTING ALLOYS. Erokhin, A. A.; Shorshorov, M. Kh.; Chernyshova, T. A. pp 145-53 of Fiziko-Khimicheskie Issledovaniya Zharoprochnykh Splavov. /Ageev, N. V. (ed.). Moscow; Izdatel'stvo Nauka (1968). (In Russian).

The resistance of the metal in the weld seams of niobium alloys to the formation of hot cracks was investigated on an industrial test sample. It was found that hot cracks are produced in the seams after solidification of the puddle. Crystallite boundaries were the site of preferential seam fracture. Their arbitrary disposition with respect to the forms of primary crystallization was determined by thermally activated migration to spatial positions with less boundary energy. Pursuing existing ideas concerning the effects of alloying on intercrystallite fracture, a condition was formulated whereby the technological strength of weld seams is determined by the relation between the rate of intergranular slip and the rate of grain boundary migration. The region of alloy compositions with low technological strength was limited by the concentration of alloying additions at which the rate of grain boundary migration was greater than the rate of intergranular slip and by the minimum value of intergranular slip rate which assures hot crack formation. Results of tests of a nickel–chromium alloy with different additions of tungsten and molybdenum are given. (JPRS)

**14765** EFFECTS OF HYDROGENATION ON THE THERMAL EXPANSION OF A ZIRCONIUM ALLOY WITH 2.5 PERCENT NIOBIUM. Rodchenkov, B. S.; Lupakov, I. S.; Kuz'michev, Yu. S.; Vukolova, V. N. Fiz. Khim. Mekh. Mater.; 5: 602-6(1969). (In Russian).

The effects of the hydrogen content and hydride orientation on the thermal expansion of a Zr–2.5% Nb alloy at 20 to 500°C was studied. It is shown that for calculation of tensions in the prepared materials it is necessary to consider changes in the coefficient of linear expansion and oscillations in the volume of the metal. (tr-auth)

**14766** ESTIMATION OF THE HIGH TEMPERATURE CREEP OF POLYCRYSTALLINE TUNGSTEN BY DETERMINATION OF PROLONGED HOT HARDNESS. Golovanov, Yu. N.; Tsvetaev, A. A.; Balakhovskii, O. A.; Chuzhko, R. K. (Inst. of Physical Chemistry, Moscow). Fiz. Khim. Mekh. Mater.; 5: 628-30(1969). (In Russian).

The creep of recrystallized polycrystalline tungsten, obtained by precipitation from a gaseous phase, was measured at 1000, 1100, and 1200°C in a vacuum. (M.C.G.)

**14767** VISCOSITY OF URANIUM AND TWO URANIUM–CHROMIUM ALLOYS. Finucane, J. S.; Olander, D. R. (Univ. of California, Berkeley). High Temp. Sci.; 1: 466-80(Dec 1969).

The viscosity of liquid uranium and the 2.2 and 4.1 wt % chromium–uranium alloys was measured with an oscillating crucible viscometer. (auth)

**14768** SOME EFFECTS OF A TEMPERATURE GRADIENT ON KNUDSEN EFFUSION. Storms, Edmund (Los Alamos Scientific Lab., N. Mex.). High Temp. Sci.; 1: 456-65(1969).

Temperature gradients in a Knudsen effusion cell were found to produce serious errors when vapor pressure measurements were made. A quantitative study, that suggests means of detecting and eliminating these gradients and a cell design, which has been proven valuable in reducing the gradient effect, are described. (auth)

**14769** DETECTION OF FATIGUE CRACK GROWTH BY ACOUSTIC EMISSION TECHNIQUES. Dunegan, H. L.; Harris, D. O.; Tetelman, A. S. (Univ. of California, Livermore). pp 20-31 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).

See CONF-690437.

It was well established in tensile tests that acoustic emission was an irreversible process that was associated with plastic deformation. It was also widely recognized that plastic deformation was present at the root of a sharp crack in a structure that was stressed. Acoustic emission tests performed on cracked fracture toughness specimens confirmed that acoustic emission associated with the plastic zone at the crack tip was also very nearly irreversible for stress intensities at the crack tip of less than one-half the critical stress intensity value required to cause unstable fracture. It is shown in this report how this irreversible feature can be utilized in a practical NDT test on a structure undergoing crack growth due to cyclic loading or other environmental effects. This technique is based on periodic acoustic emission monitoring of a structure as it is loaded back to its proof stress. (auth)

**14770** COMPARISON OF INCONEL 718 AND ALUMINUM 2219 FOR A HIGH-PRESSURE HYDROGEN VESSEL. Taylor, Jack L. (California Inst. of Tech., Pasadena). Contract NAS 7-100. pp 420-31 of Proceedings of the Seventh Symposium on Nondestructive Evaluation of Components and Materials in

Aerospace, Weapons Systems, and Nuclear Applications, April 23–25, 1969, San Antonio, Texas. North Hollywood, Calif.; Western Periodicals Company (1969).
See CONF-690437.

In order to select a material for a 6-in. dia spherical, high-pressure hydrogen vessel for a long-lived spacecraft application, aluminum 2219-T6E46 and Inconel 718 alloy surface-flawed-specimens were tested to determine fracture toughness and flaw growth in 5200-psig high-purity hydrogen at room temperature. The vessel of Inconel was designed with a 0.120-in. wall to contain hydrogen at 5200 psig, and the aluminum vessel with a 0.345-in. wall for hydrogen at 6000 psig. For Inconel 718, the critical stress intensity in plane strain ($K_{Ic}$) was 150 ksi $\sqrt{\text{in.}}$, whereas the threshold stress intensity in plane strain ($K_{TH}$) was only 22 ksi $\sqrt{\text{in.}}$ in hydrogen. An Inconel 718 vessel could withstand a proof test at 90% of yield stress while containing a flaw nearly 0.120 in. deep. In hydrogen, however, the threshold flaw size at operating stress ($\sigma_{op}$) is 0.032 in.; i.e., a flaw ≃0.035 in. deep would grow through in ≃100 hr. Since nondestructive testing (NDT) could not be relied on to find all flaws as small as 0.032 in., Inconel 718 was judged unacceptable. In contrast, aluminum 2219 had a $K_{Ic}$ value of 35 ksi $\sqrt{\text{in.}}$ and in hydrogen a $K_{TH}$ of 28 ksi $\sqrt{\text{in.}}$ Thus, the aluminum 2219 vessel could pass a proof test at 90% of yield stress with a flaw as deep as 0.187 in. Here, NDT could be relied on to ensure that there would not be a proof-test failure, an important consideration for costly vessels. The threshold flaw size at $\sigma_{op}$ was 0.270 in., giving a wide margin (0.083 in.) for flaw growth under cyclic loading and assuring no growth for sustained loading. (auth)

**14771** PHYSICAL NATURE OF HIGH TEMPERATURE CREEP OF NIOBIUM. Abramyan, E. A.; Ivanov, L. I.; Yanushkevich, V. A. (Inst. of Metallurgy, Moscow). Fiz. Metal. Metalloved.; 28: 496-500(Sep 1969). (In Russian).

Creep studies were made on single crystals and polycrystals of niobium with various purities at 1300 to 1900°C and at 36 to 230 kg/cm². It was found that the energy of activation of creep does not depend on pressure. The relation is increased with the decrease of the metal purity. The microstructure of the crystals was studied before, during, and after plastic deformation. (tr-auth)

**14772** HIGH COMPRESSION OF BERYLLIUM CRYSTALS. Papirov, I. I.; Tikhinskii, G. F.; Borovkov, A. N.; Islankina, N. F.; Beresnev, B. I.; Martynov, E. D.; Pakhomov, Ya. D. (Physical-Technical Inst., Kharkov). Fiz. Metal. Metalloved.; 28: 524-7(Sep 1969). (In Russian).

Monocrystals of beryllium of 99.0 and 99.95% purity were compressed along the axis at room temperature and at 1 and 10,000 to 12,000 kg/cm². A change of plastic deformation mechanism was discovered at high pressures occurring with a pyramidal glide along the $(10\bar{1}3)$ or $(11\bar{2}5)$ planes. It was found that the disintegration depends on the purity of the crystals. (tr-auth)

**14773** CREEP BEHAVIOR OF MOLYBDENUM SINGLE CRYSTALS. Clauer, A. H. (Battelle Memorial Inst., Columbus, Ohio); Wilcox, B. A.; Hirth, J. P. Acta Met.; 18: 367-79(Mar 1970).

The creep behavior of molybdenum single crystals oriented with a [011] direction parallel to the tensile axis was investigated over the temperature range 1200 to 1917°C (0.5 to 0.76 $T_m$). The activation energy for creep at applied stresses of 900 and 2050 psi was 108 and 105 kcal/mol, respectively. No steady state creep was observed, although the creep rate was approaching a constant value at 0.45 creep strain. The transient creep strain was fitted to a relation $\epsilon = \epsilon_0 + bt^m$, yielding $b \propto \sigma^{3.8}$ at 1410°C, and $0.37 < m < 0.71$, with m increasing with increasing temperature. The analysis of slip bands and Laue back reflection patterns indicated that {112}⟨11⟩ was the primary slip mode for [011] crystals crept at these temperatures. The slip distribution was very non-uniform, being concentrated into regularly spaced, narrow bands. The slip band spacing decreased with increasing stress. (auth)

**14774** DISLOCATION SUBSTRUCTURE INDUCED BY CREEP IN MOLYBDENUM SINGLE CRYSTALS. Clauer, A. H. (Battelle Memorial Inst., Columbus, Ohio); Wilcox, B. A.; Hirth, J. P. Acta Met.; 18: 381-97(Mar 1970).

The dislocation substructure formed during creep of molybdenum single crystals of ⟨110⟩ axial orientation was investigated. The strain dependence of the substructure was examined by etch-pitting techniques after creep at 900 psi and 1650°C. Transmission electron microscopy studies were performed on specimens after creep to various strains at 2000 psi and 1410°C. The etch-pitting studies showed that the substructure consisted of bands of narrow subgrains separated by bands of coarser subgrains. This general structure persisted for all creep strains. The transmission electron microscopy studies showed that edge dislocations predominated in the creep substructure. The sub-boundaries were identified as {111} tile boundaries composed of dislocations from the two predominant slip directions. Short segments of {100} tilt boundaries were associated with the {111} tile boundaries. Etch-pitting showed that the density of the dislocations not associated with the sub-boundaries decreased with increasing creep strain. The nonuniformity of the slip deformation was related to the non-uniformity of the substructure and to the influence of long-range stress fields of tilt boundaries on dislocation glide. (auth)

## *Structure and Phase Studies*

**14775** (IS-T-344) LATTICE DYNAMICS OF YZn. Prevender, Thomas Stephen (Iowa State Univ. of Science and Technology, Ames). Nov 1969. 123p. Dep. CFSTI.
Thesis.

A series of experiments and calculations have been performed involving the ordered alloy YZn. The primary experiment was a measurement of the phonon dispersion curves along the (0 0 ζ), (ζ ζ 0), (ζ ζ ζ) and (½ ½ ζ) symmetry directions by the use of inelastic neutron scattering. A general sixth neighbor force constant model was found to be necessary to satisfactorily describe the dispersion curves. However, a Fourier analysis of the sums of the squares of the phonon frequencies along symmetry directions indicated that longer range forces were present. The long-range order parameter was determined by means of an x-ray diffraction experiment. A method of analysis of this experiment was derived that not only revealed the sample to be extremely well-ordered but also indicated that the mean square displacement of Y was greater than that of Zn. The analysis also yielded an approximate value for the sum of the mean square displacements. The elastic constants of YZn were determined by means of an ultrasonic pulse superposition technique. With the use of the measured elastic constants a simple first neighbor force constant model was devised to describe the lattice properties. YZn was also investigated to determine whether it is a superconductor. In tests to temperatures as low as 1.2°K no evidence for a superconducting transition was found. The frequency distribution function of normal modes, lattice specific heat, Debye temperature and atomic mean square displacements were calculated for both the first and sixth neighbor models. In addition, the structure factor for inelastic one-phonon coherent scattering was calculated from the sixth neighbor model. An evaluation of the effectiveness of the simple first neighbor model in predicting lattice properties was made. (auth)

**14776** (SRO-552-2) QUANTITATIVE DETERMINATION OF THE STRUCTURE, PROPERTY RELATIONSHIPS IN NUCLEAR FUEL ELEMENT MATERIALS. Quarterly Progress Report, September 15–December 15, 1969. Rhines, F. N.; DeHoff, R. T.; Hench, L. L. (Florida Univ., Gainesville. Engineering and Industrial Experiment Station). Jan 1970. Contract AT(38-1)-552. 19p. Dep. CFSTI.

The design and preliminary operation of the devices to be used in sample preparation and property measurements were completed. The permeability apparatus was designed and constructed. The initial measurement of permeability of a porous nickel sample is reported. Dies for presintering tensile bars for room temperature tensile property measurements for nickel have been designed and are being fabricated. Sizing of the nickel powder is nearing completion. A qualitative characterization of the $UO_2$ powder, including scanning electron micrographs, is reported. (J.C.W.)

**14777** TRANSFORMATION REACTION AND CORROSION BEHAVIOUR OF TWO ZIRCONIUM–COPPER–MOLYBDENUM ALLOYS. Skelly, H. M.; Dixon, C. F. Ottawa; Department of Energy, Mines, and Resources (1969). 31p. $0.75. (R-204).

The transformation reaction for a Zr–1.0% Cu–1.5% Mo alloy quenched from the beta phase at 1000°C and aged at 500°C was shown to be: $\omega + \beta \rightarrow \alpha' \rightarrow \alpha + Zr_2Cu + ZrMO_2$. The corrosion resistance of this alloy and of a Zr–0.5% Cu–0.5% Mo alloy was found to be related to the structures produced by the transformation reaction. Optimum corrosion resistance was obtained after aging for 32 and 24 hr, respectively. Aging of specimens resulted in an increase in the size of the intermetallic particles; and larger $ZrMo_2$ particles in overaged specimens appeared to corrode at a rate greater than the matrix, causing cracking of the corrosion film and resulting in an accelerated corrosion rate for the specimens. The type of corrosion film, like the corrosion rate, was affected by structural changes produced by the transformation reaction. (auth) (Canada)

**14778** STRUCTURE AND SUPERCONDUCTIVITY OF TERNARY MOLYBDENUM–PLATINUM–RHENIUM ALLOYS. Roeschel, Erich; Raub, Ernst. Z. Metallk.; 61: 71-6(Jan 1970). (In German).

The structure of molybdenum-rich molybdenum–platinum–rhenium alloys was determined on isothermal sections at 1050, 1600, and 1800°C. In molybdenum-rich ternary alloys only phases which occurred in the binary system were found. Rhenium stabilized the A15 molybdenum–platinum phase to higher and lower temperatures. Measurements of the transition temperature for normal to superconductivity indicated general agreement with previous measurements on the binary molybdenum–platinum and molybdenum–rhenium alloys. The transition temperature was not increased by the formation of the A15 phase in the ternary alloys; it increased with increasing rhenium content but did not exceed the value for the saturated A2 solid solution. The transition temperature in the ternary A2 solid solution decreased with increasing platinum content at constant rhenium content. In general the transition temperature of the ternary A2 phase was lower than in the corresponding binary solid solution. Ternary alloys in which the $\sigma$ phase was formed exhibit a minimum in transition temperature. (auth)

**14779** RELATIVE STABILITY OF VARIOUS STACKING ORDERS IN CLOSE-PACKED METAL STRUCTURES. Havinga, E. E.; van Vucht, J. H. N.; Buschow, K. H. J. Philips Res. Rep.; 24: 407-26(Oct 1969).

Theoretical considerations mainly involving long-range interactions are presented in order to explain the occurrence of the observed types of close-packed structures in metallic elements, intermetallic compounds, and alloys. The theory is based on the long-ranged oscillating forces due to the screening of the atomic potentials by the valence electrons. These forces can be summed in the way indicated by Blandin et al. to an effective interaction between close-packed planes. The method is essentially a simple semi-quantitative approximation of Brillouin-zone effects. As it is based on a nearly-free-electron model it is only applied to non-transition metals and alloys. The refinement applied includes the following: a screening, due not only to the finite free paths of the Fermi electrons, but also due to the finite values of the pseudopotentials; relativistic effects, which for many metals are equally important as the nonrelativistic scattering of the Fermi electrons; and a volume effect in ordered $AB_3$ compounds, depending on the radius ratio of the atoms A and B. The results are compared with the experimental facts for the metallic elements, the inter-rare-earth alloys, the rare-earth thorium alloys, and for intermetallic compounds $AB_3$. The theory is less successful for the alloys of the noble metals with multivalent elements. In the system $BaPb_3$–$BaTl_3$ a new structure type, predicted by the theory, was actually found and is described. Structure data of new phases found in the systems of thorium with Sm, Gd, Tb, Dy, Ho, Er, and Y, respectively, for some $RAl_3$ allotropes, and for a compound Er $(Pd_{0.67}Au_{0.33})_3$ are reported. (auth)

**14780** THE NEODYMIUM–, SAMARIUM–, AND TERBIUM–MANGANESE PHASE DIAGRAMS. Kirchmayr, Hans Rudolf; Lugscheider, Walter (Technische Hochschule, Vienna). Z. Metallk.; 61: 22-3(Jan 1970). (In German).

The phase diagrams for the neodymium-manganese, samarium-manganese and terbium-manganese systems are given. They are based on x-ray diffraction, differential thermal, and micrographic investigations. (auth)

**14781** CRYSTAL STRUCTURE OF COMPOUNDS OF FORMULA 5:4 FORMED BETWEEN RARE EARTHS AND LEAD. Merlo, Franco; Fornasini, Maria L. Atti Accad. Naz. Lincei, Rend., Cl. Sci. Fis., Mat. Natur.; 46: 265-9(Mar 1969). (In Italian).

The crystal structures of phases with the composition $M_5Pb_4$ have been examined for the rare earth metals (M = La, Ce, Pr, Nd, Sm, Gd, Tb, Dy, Ho, Er, and Tm) by micrographic and x-ray powder method. All the phases examined crystallize in the orthorhombic $Sm_5Ge_4$ structure type. The lattice constant values of all these compounds and intensity data for $La_5Pb_4$ are given. (auth)

**14782** THE INVESTIGATION OF OXYGEN COMPOUNDS OF NIOBIUM IN REGION OF $NbO_2$–$Nb_2O_5$. Burdeze, A.; Tkachenko, E. V.; Abbattista, F. (Turin Polytechnic Inst. Ural State Univ., Sverdlovsk, USSR). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1957-62(Nov 1969). (In Russian).

Niobium oxides were studied in the region of $NbO_2$–$Nb_2O_5$. The existence of $NbO_{2.432}$ was established and the x-ray phase characteristics and thermal stability are described. The closeness of $NbO_{2.458}$ and $NbO_{2.454}$ was indicated. The conditions for the existence of $NbO_{2.49}$ were found to be in complete agreement with data obtained on the reactions of niobium oxides synthesis and the reactions of equilibrium reduction of $Nb_2O_5$. (tr-auth)

**14783** PHASE RATIOS IN Ni–Nb–O SYSTEM IN REGION OF Ni–NiO–$Nb_2O_5$–$NbO_2$ AT 1250°C. Tkachenko, E. V.; Abbattista, F.; Burdeze, A. (Ural State Univ., Sverdlovsk, USSR. Turin Polytechnic Inst.). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1963-8 (Nov 1969). (In Russian).

Studies were made on the existence of $(Nb, Ni)O_{2.58}$, $(Nb, Ni)O_{2.478}$, $(Nb, Ni)O_{2.45}$, $(Nb, Ni)O_{2.432}$, and $(Nb, Ni)O_{2.0}$ isostructural to the corresponding pure oxides of niobium. The cross-section of the phase diagram of the system Ni–Nb–O in the region $Nb_2O_5$–$NbO_2$–Ni–NiO at 1250°C was constructed. (auth)

**14784** ABNORMAL INCREASE OF GRAINS AND FORMATION OF MONOCRYSTALS DURING ANNEALING OF HYDROEXTRUDED MOLYBDENUM. Mochalov, G. A.; Martynov, E. D.; Beresnev, B. I.; Evstyukhin, A. I.; Bulychev, D. K.; Rusakov, A. A.; Rodionov, K. P.; Ryabinin, Yu. N. (Moscow Engineering Physics Inst. Inst. of Physics of Metals, Moscow). Fiz. Metal. Metalloved.; 27: 870-2(May 1969). (In Russian).

The effects of hydroextrusion on the recrystallization of molybdenum were studied. It was established that hydroextruded molybdenum showed tendencies towards abnormal grain growth during secondary recrystallization. During annealing at ~2000°C, molybdenum rods were transformed to monocrystals. (tr-auth)

**14785** NEW METHOD FOR PREPARING UNUSUALLY ORIENTED TUNGSTEN TIPS AND THEIR GROWTH MECHANISM. Okuyama, Fumio; Hibi, Tadatosi (Tohoku Univ., Sendai). Jap. J. Appl. Phys.; 9: 15-23(Jan 1970).

A new method for preparing tungsten tips having an unusual orientation, for example, the [100]- or the [111]-orientation, was studied using a field emission microscope. It was found that tungsten tips having the [100]- or the [111]-orientation could be obtained with heat treatment of the tip at low temperature (1500–2300°K) after introducing air or oxygen into the experimental tube. To make clear the mechanism of the change in the tip orientation from the normal orientation to the unusual one, light- and electron-microscopic observations of the cathodes were carried out. As a result, it became clear that the growth mechanism of the unusual tip could be explained by assuming that the tungsten tip rotated around a fixed ⟨110⟩-axis under the tungsten carbide film so as to transfer to the stable state from a semi-stable state. (auth)

**14786** ELECTRON MICROSCOPE INVESTIGATION OF STRUCTURE OF INDIUM OXIDE FILMS. Vaisfel'd, N. M.; Sokolina, V. A.; Fialkovskya, R. P. Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 2095-8(Dec 1969). (In Russian).

The structure of $In_2O_3$ was investigated with an electron microscope. After pulverization, polycrystalline indium oxide revealed fine-grained structure with great homogeneity in relation to the particle dimensions and their morphologies. It was found that $In_2O_3$ films are formed from two or three layers of crystals which are close to the thickness of the film. The annealing of films at 550 to 1000°C does not produce visible changes of the structure. Treatment at higher temperatures changes crystal morphology and recrystallizations. (tr-auth)

**14787** PHASE DIAGRAM OF SCANDIUM–OXYGEN. Kuprashvili, I. S.; Naumkin, O. P.; Savitskii, E. M. (Inst. of Metallurgy, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 2123-7(Dec 1969). (In Russian).

The phase diagram of scandium–oxygen was constructed after x-ray and thermal analyses and measurement of properties. The phase diagram is characterized by the presence of the eutectic transformation at 1560 ± 10°C and approximately 35 at. % oxygen, and the eutectoid transformation at 1130 ± 10°C and approximately 16 at. % oxygen. The maximum solubility in beta-Sc constitutes approximately 33 at. % at the eutectic temperature and approximately 11 at. % at the eutectoid temperature. The comparison of the maximum solubility of oxygen in solid state transitional metals of Groups IIIA, IVA, and VA, showed that the maximum solubility of oxygen takes place in transitional metals with the minimum content of electrons on the D-shell according to the smallest atomic number. (tr-auth)

**14788** PHASE DIAGRAM OF $Dy_2O_3$–$Cr_2O_3$. Shevchenko, A. V.; Lopato, L. M.; Pavlikov, V. N. (Inst. of Problems of Material Studies, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 2128-32(Dec 1969). (In Russian).

In the phase diagram of $Dy_2O_3$–$Cr_2O_3$ at 1600 to 2400°C, a melted compound with a ratio of 1 to 1 was found at 2320 ± 30°C. The compound forms eutectics with $Dy_2O_3$–$Cr_2O_3$. The crystal-optic properties of $DyCrO_3$ were determined. By DTA, the phase transformations in the dysprosium oxide-rich region were studied. It was established that the temperatures of the polymorphic transformations during heating are 1950 ± 10 and 2130 ± 20°C. (tr-auth)

**14789** TERNARY SYSTEM NIOBIUM–NICKEL–SILICON. Gladyshevskii, E. I.; Koshel, O. S.; Skolozdra, R. V. (Lvov

State Univ.). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 2202-4(Dec 1969). (In Russian).

Phase equilibrium in the Nb–Ni–Si system was studied by x-ray and microstructure analyses. Eighty-one specimens were melted in an electric arc in a pure Ar atmosphere. The phase diagram of an annealed specimen was constructed and analyzed. (tr-auth)

**14790** IRON–HOLMIUM BINARY SYSTEM AND RELATED MAGNETIC PROPERTIES. Roe, Gerald John. Rolla, Mo.; Univ. of Missouri (1969). 119p.

Thesis.

The iron-holmium phase diagram was investigated to determine the alloying behavior of these two metals and to determine the magnetic properties of some of the iron-holmium alloys which formed intermediate phases. The iron-holmium binary system was determined by three experimental techniques, differential thermal analysis (DTA), x-ray diffraction, and metallography. A phase diagram with three eutectic points and four intermediate phases was constructed from the experimental data. The two phases, $Ho_6Fe_{23}$ and $Ho_2Fe_{17}$, melted congruently at 1332 and 1343°C respectively. $HoFe_2$ and $HoFe_3$ melted incongruently at 1288 and 1293°C respectively. Neutron diffraction investigations were made on the intermediate phases $Ho_6Fe_{23}$ and $HoFe_2$ to obtain information on their magnetic structures. From the plots of magnetic ordering vs temperature, the Curie temperature of $Ho_6Fe_{23}$ was placed at 500°K, and that of $HoFe_2$ at 600°K. Intensity calculations for the $Ho_6Fe_{23}$ data showed a ferrimagnetic structure with saturation moments of 2.25 and 9.3 $\mu_B$ for iron and holmium respectively. The magnetic and chemical cells of $Ho_6Fe_{23}$ were coincidental, while the magnetic cell of $HoFe_2$ was approximately four times larger than its chemical cell. (Diss. Abstr. Int., B)

**14791** VACANCY DECAY AT -21.3°C IN QUENCHED ALUMINUM–INDIUM ALLOYS. Plumbridge, W. J. (Inst. of Science and Tech., Manchester, Eng.). Scr. Met.; 4: 85-6(Feb 1970).

Resistivity measurements of the vacancy decay process in these alloys at an aging temperature of −21.3°C were made. Data for aging of zone refined Al and Al alloys containing 2 and 7 ($\times 10^{-5}$) atom fraction of In are presented graphically as isothermal anneal-curves. (J.R.D.)

**14792** FLOW STRESS OF NIOBIUM AND NIOBIUM–MOLYBDENUM ALLOYS IN THE SUPERCONDUCTING AND NORMAL STATES. Kostorz, G. (Argonne National Lab., Ill.). Scr. Met.; 4: 95-100(Feb 1970).

The energy for thermally activated dislocation movement as related to the transition from superconductivity state to the normal state in Nb is considered. The data presented show that no measurable increment of flow stress strain rate occurs when magnetic fields are applied to the specimens. These data cannot be interpreted in terms of simple electron drag models. Explanations of these phenomena are offered and measurements of flow stress in the mixed state of pure Nb, and flow stress in the superconducting and normal state for dilute Nb alloys containing Mo are presented. (J.R.D.)

**14793** ON THE MISCIBILITY GAP IN THE IRON–CHROMIUM–VANADIUM TERNARY SYSTEM. Mima, Genjiro; Yamaguchi, Masaharu (Osaka Univ.). J. Jap. Inst. Metals; 33: 1308-13 (Nov 1969). (In Japanese).

The effect of vanadium addition on the miscibility gap in the iron–chromium binary system was investigated by differential thermal analysis and Moessbauer effect measurements. The miscibility gap obtained experimentally in the iron–chromium–vanadium ternary system was qualitatively in agreement with that predicted from thermodynamic data of three binary systems, iron–chromium, iron–vanadium, and chromium–vanadium systems. The ternary tie-lines were determined by means of the Moessbauer measurements of the binary and ternary alloys aged at 480°C. It was found that when the ternary tie-lines were extrapolated the lines cut the iron–chromium binary line at the point at which the chromium content was nearly 90 at.%. (auth)

**14794** HYDRIDE BANDING IN EXPERIMENTAL ZIRCONIUM/2.5 WT PERCENT NIOBIUM PRESSURE TUBES. Aldridge, S. A. (Atomic Energy of Canada Ltd., Chalk River, Ont.). J. Nucl. Mater.; 34: 209-11(Feb 1970).

Hydride banding in heat-treated zirconium/2.5 wt % niobium pressure tubes was investigated. Hydride banding occurred in tubes that were $\beta$ quenched prior to extrusion and was independent of subsequent deformation. (G.M.C.)

**14795** PRECIPITATION OF TRACE AMOUNTS OF BORON IN AISI 304 L AND AISI 316 L. Elen, J. D.; Glas, A. (Reactor Centrum Nederland, Petten). J. Nucl. Mater.; 34: 182-8(Feb 1970).

The technique of boron topography, based on observation of damage tracks from the $^{10}B(n,\alpha)^7Li$ nuclear reaction, was used to study the distribution of 3 to 50 ppM boron in 304 L and of 1 to 35 ppM boron in 316 L. It was found that the solubility in 304 L was less than 9 ppM at temperatures below 1000°C. Boron was partly segregated at the grain boundaries. If cold work was present, boron was attached to dislocations during recovery. Dislocation pinning retarded recrystallization. The segregation of 35 ppM boron in 316 L was essentially slower, probably due to the strain-field of dissolved molybdenum. (auth)

**14796** PRECIPITATION BEHAVIOR IN Zr/2.5 WT PERCENT Nb ALLOYS. Sabol, G. P. (Westinghouse Research Labs., Pittsburgh). J. Nucl. Mater.; 34: 142-50(Feb 1970).

The hardness response and structure of high-purity and commercial purity Zr/2.5 wt % Nb alloys were studied as a function of aging treatment. In both alloys, the age hardening increment was small but finite, and the aging curves were characterized by two hardness peaks separated by a hardness trough. Correlation of the hardening response with microstructure revealed that the samples aged to the first hardness peak were characterized by a fine spherical precipitate of about 100 Å diameter. At aging times corresponding to the second hardness peak, this fine precipitate was replaced by a needle-like precipitate. This sequence of precipitation was valid for both the high-purity and commercial alloys, however, precipitation kinetics were more sluggish in the commercial alloy. (auth)

**14797** SHORT-RANGE ORDER IN URANIUM–NIOBIUM SOLID SOLUTION. Strelova, S. V.; Umanskii, Ya. S.; Ivanov, O. S. (Inst. of Metallurgy, Moscow). J. Nucl. Mater.; 34: 160-4(Feb 1970).

The short-range order in mutual arrangement of atomic components in uranium–niobium solid solution of equiatomic composition was studied by an x-ray diffuse scattering method. It was established that atoms of uranium mainly surround atoms of niobium and vice versa. The short-range order parameters were measured for three shells and the static distortion parameters of the crystal lattice due to differences in the atomic volumes of the components were determined too. (auth)

**14798** STUDY BY TRANSMISSION ELECTRON MICROSCOPY OF PRECIPITATION IN AN IRON–NICKEL–CHROMIUM–MOLYBDENUM ALLOY WITH SPECIAL THERMOELASTIC PROPERTIES. Mazaud, Jean-Claude; Vial, Antonin (Laboratoire de Metallurgie, Isere, France). Compt. Rend., Ser. C; 269: 1257-60(24 Nov 1969). (In French).

Transmission electron microscopy was used to study the precipitation at 700°C in a Cr–Fe–Mo–Ni alloy containing about 0.5% Be. After treatment at 700°C for more than 30 min, observation of the matrix showed the continuous precipitation of a partially coherent Ni–Be phase designated by $\beta'$. $\beta'$ has a centered tetragonal structure with parameters a = 2.53 Å and c = 2.64 Å. The relations of orientation of $\beta'$ in the matrix was shown to be coherent in its basal plane and noncoherent in the direction of the $\vec{c}_\beta$ axis. (tr-auth)

**14799** LEED STUDY OF STEPS AND FACETS ON A Re SURFACE. Feinstein, L. G.; Macrakis, M. S. (Electronics Research Center, Cambridge, Mass.). Surface Sci.; 18: 277-92(Dec 1969).

A rhenium single crystal with an initial (0001) orientation, recrystallized by twinning to yield {10$\bar{1}$n} planes parallel to the surface, is discussed. The low energy electron diffraction (LEED) pattern displayed a one-dimensional superstructure which could be attributed to a system of regularly spaced steps. The 00 beam was diffracted from the (0001) plateaus of the steps, and not the high index plane. Heating the crystal in oxygen apparently modified the step system. Residual gas analysis showed that even after a clean LEED pattern was obtained, carbon contamination was removed from the surface as CO by heating the sample in oxygen. Electropolishing of Re(0001) may result in basal plane etching. The faces of the rhombohedral pyramids thus formed were determined by analysis of LEED patterns and photomicrographs to be {11$\bar{2}$n}, n = 2, 3, 4. The facet reflections were shifted in energy with respect to the normal reflections, due to a difference in inner potential. Also a dynamic interaction between the two sets of beams was suggested by observations. An intensity versus voltage plot for the normal 00 beam exhibited forbidden Laue maxima out to the 21st order. The absence of all but two secondary Bragg peaks may be explained with an Ewald sphere construction. (auth)

**14800** DETERMINATION OF NICKEL–MOLYBDENUM SURFACE ALLOY STRUCTURES USING LEED. Feinstein, L. G. (Electronics Research Center, Cambridge, Mass. Laboratoire d'Electrostatique et de Physique du Metal, Grenoble, France); Blanc, E. Surface Sci.; 18: 350-6(Dec 1969).

Four well-ordered surface alloys in the Ni–Mo system were investigated by LEED. The alloys were obtained by surface diffusion

of Mo onto a Ni(111) face at temperatures between 650 and 950°C. The probable structures of the alloys were determined with the aid of tabulated symmetry and extinction properties of the 2-D space groups, and the phase diagram of the system. A $5 \times 5$ and a $4 \times 4$ superstructure possessing the hexagonal symmetry of the Ni(111) mesh with 4 and 6 at.% Mo, and two rectangular structures containing 15 and 20 at.% Mo were found. No surface structures corresponding to the bulk alloys $Ni_4Mo$ or $Ni_3Mo$ were detected. (auth)

**14801** CRYSTALLOGRAPHY OF THE PHASE TRANSFORMATIONS FROM THE GAMMA REGION OF THE $UMo_{1.1}$ ALLOYS BY WEIGHT. Brun, Gilbert; Decours, Jacques; Khan, Tasadduq (CEN de Saclay, Gif-sur-Yvette, France). Compt. Rend., Ser. C; 269: 1370-3(3 Dec. 1969). (In French).

The different processes of phase transformations from the γ region of the $UMo_{1.1}$ alloys by weight have been studied by microscopy and electron microdiffraction. (tr-auth)

**14802** EFFECT OF TEMPERATURE DURING DEFORMATION ON THE DEVELOPMENT OF TEXTURE IN ZIRCONIUM ALLOY ROLLED SHEET. Cheadle, B. A.; Aldridge, S. A.; Ells, C. E. (Atomic Energy of Canada Ltd., Chalk River, Ont.). J. Nucl. Mater.; 34: 119-24(Jan 1970).

The texture of Zr/2.5 wt % Nb sheet, heated to 700 to 1050°C and then deformed 80 to 90% by rolling between cold rolls, was studied. After rolling at 700 and 800°C the texture was similar to that of the cold rolled sheet. However, the material rolled at 1000°C had a large component of basal plane normals aligned near the rolling direction. (G.M.C.)

**14803** $Ni_3Ta$ IN NICKEL-RICH Ni–Ta ALLOYS. Larson, J. M.; Taggart, R.; Polonis, D. H. (Univ. of Washington, Seattle). Met. Trans.; 1: 485-9(Feb 1970).

An ordering reaction has been observed in the nickel-rich binary alloys of the Ni–Ta system that are aged below 570°C following quenching from elevated temperatures. This reaction has been investigated by employing electron diffraction microscopy, x-ray diffraction, and electrical resistivity techniques. The ordered phase has been identified as $Ni_3Ta$ and its structure is identical to that of the $Ni_3Nb$ reported earlier. In the stoichiometric $Ni_3Ta$ alloy (Ni-11.1 at.% Ta) three variants of the $Ni_3Ta$ phase appear to be nucleated homogeneously throughout the matrix. The precipitate or domain morphology has been identified as a cuboid elongated in one direction such that the cube faces are parallel to the {100} planes of the matrix. The cuboid morphology of the precipitates tends to disappear as the precipitates coalesce and the particle size approaches 1000 Å. (auth)

**14804** THE ANTI-$Th_3P_4$-TYPE STRUCTURE IN THE LANTHANUM–RHODIUM SYSTEM: $La_4Rh_{\sim 3}$. Virkar, A. V.; Singh, P. P.; Raman, A. (Louisiana State Univ., Baton Rouge). Inorg. Chem.; 9: 353-6(Feb 1970).

$La_4Rh_{\sim 3}$ has the anti-$Th_3P_4$-type structure, with $a = 8.922$ (±3) Å. The space group is $I\bar{4}3d$-$T_d^4$. About $11\frac{2}{3}$ Rh atoms are randomly distributed in 12(a): $\frac{3}{8}$, 0, $\frac{1}{4}$. Sixteen La atoms are in 16(c): x, x, x, where $x = 0.0570$ (±5). The interatomic distances are: Rh–La, 2.851 (±5) and 3.357 (±4) Å; La–La, 3.591 (±7), 3.863 (±2), and 4.122 (±6) Å. The Rh atoms are not in contact with each other. The shortened Rh–La bond length, 2.851 Å, indicates some covalent bonding. The causes for the change in stoichiometry from $A_3B_4$ to $A_4B_3$, where A is always a transition element, and the variations in the positional parameter x between 0.057 and 0.083 are discussed in terms of the sizes and the chemical nature of the B atoms. (auth)

**14805** TRANSFORMATIONS DURING CONTINUOUS COOLING OF THE ALLOY $UMo_{1.1}$ BY WEIGHT FROM THE GAMMA REGION. Decours, Jacques; Brun, Gilbert (CEN de Saclay, Gef-sur-Yvette, France). Compt. Rend., Ser. C; 269: 1179-82 (17 Nov 1969). (In French).

The study, during continuous cooling, by dilatometry and thermal analysis of the alloy $UMo_{1.1}$ has shown two or three regions, according to the shape of the gamma grain, where the transformations were produced by germination and growth. The temperatures of the beginning and the end of the transformations were increased by 10 to 20°C when the alloy consisted of fine gamma grains. Carbon had little influence on the kinetics of transformation. (tr-auth)

**14806** MACRO- AND MICRODEFORMATION IN Mo AND Mo–Re POLYCRYSTALS DURING SINGLE AXIS EXPANSION. Gezalov, M. A.; Betekhtin, V. I.; Slutsker, A. I. (Ioffe Inst. of Physics and Tech., Leningrad). Fiz. Metal. Metalloved.; 28: 541-4(Sep 1969). (In Russian).

The curved expansions of crystalline lattice (microdeformation) were compared with the whole form (macrodeformation) polycrystals of molybdenum and molybdenum–rhenium systems by x-ray diffraction measurements. The possible causes of irregularities of deformation were examined in Mo–Re. Certain peculiarities of deformation of Mo in the plastic region were discovered and are discussed. (tr-auth)

**14807** INTERNAL FRICTION IN REGION $\alpha \rightarrow \beta$ TRANSFORMATIONS OF ZIRCONIUM. Garber, R. I.; Kharitonova, Zh. F. Fiz. Metal. Metalloved.; 28: 518-23(Sep 1969). (In Russian).

It was found that two internal friction peaks occur in the $\alpha \rightarrow \beta$ region of zirconium transformations. The first peak was connected to interphase losses. The calculated effective particle dimension of the new phase is about $8 \times 10^{-6}$ cm. The effects of changes on the structure of the background material and the second peak of internal friction were examined. It is projected that the second peak was caused by the processes of recrystallization after plastic deformation during the phase transformation. (tr-auth)

## Radiation Effects

*Refer also to abstracts 14172 and 15396.*

**14808** (BNWL–1020) IRRADIATION EFFECTS ON REACTOR STRUCTURAL MATERIALS. Quarterly Progress Report, November 1968–January 1969. Claudson, T. T. (ed.) (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Mar. 1969. Contract AT(45-1)-1830. 459p. Dep. CFSTI.

Research related to several aspects of radiation effects on reactor materials is reported. Summaries of activities at Pacific Northwest Laboratories, Argonne National Laboratory, Brookhaven National Laboratory, Idaho Nuclear Corporation, Naval Research Laboratory, and Oak Ridge National Laboratory are included. (J.R.D.)

**14809** (GEAP–10062) MECHANICAL PROPERTIES OF IRRADIATED TYPE-304 AND TYPE-316 STAINLESS STEEL IN FAST REACTORS. Comprelli, F. A.; Busboom, H. J.; Gebhardt, M. F. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Jun 1969. Contract AT(04-3)-189. 23p. Dep. CFSTI.

Data published to Nov. 1968 on the mechanical properties of irradiated Types 304, 316, and 316L stainless steel have been compiled and analyzed. Curves are given for variation of yield stress, ultimate tensile stress, uniform elongation, and total elongation as a function of test temperature. The property limits suggested for use at total fluences above $10^{22}$ nvt include yield stress at 0.2% offset: 44,000 psi at 500°C, 31,000 psi at 600°C, and 20,000 psi at 700°C; ultimate stress: 58,000 psi at 500°C, 46,000 psi at 600°C, and 30,000 psi at 700°C; uniform elongation: less than 1%; total elongation: less than 1%; minimum creep rate: unchanged to slightly increased by irradiation; time to rupture: reduced significantly by irradiation; and creep strain to fracture: as low as 1%. (J.C.W.)

**14810** (GEAP–10066) MECHANICAL PROPERTIES EVALUATION OF AUSTENITIC STAINLESS STEELS IRRADIATED IN EBR-II. Lauritzen, T.; Withop, A.; Ferguson, G. P. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Jul 1969. Contract AT(04-3)-189. 89p. Dep. CFSTI.

Tensile coupons of five austenitic materials (Types 304, 316, 321, 347, and Incoloy-800) prepared from thin-wall tubing were irradiated in EBR-II. The maximum accumulated neutron exposure was $3.4 \times 10^{22}$ n/cm$^2$, total, at 1000 to 1300°F. The mechanical properties of the irradiated coupons were determined. Post-irradiation mechanical testing included uniaxial tensile and burst (biaxial) tests at temperatures ranging from 900 to 1500°F. Light optical and electron metallography studies were conducted to characterize the mode of failure. Heat treatment for Type-304 stainless steel to produce a carbide agglomerated state was found to promote increased residual ductilities after reactor exposure. This observation, which needs confirmation, is in contrast to larger reductions in ductility (measured by percent elongation) found for all five commercial austenitic alloys used in these experiments in the as-received or mill-annealed condition. (auth)

**14811** (GEMP–1013, pp 167-223) RADIATION EFFECTS ON FAST REACTOR CLADDING AND STRUCTURAL MATERIALS. Moteff, J.; Kingsbury, F.; Smith, J. P. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Hot hardness studies of 304 SS from EBR-II subassembly XGO5 shroud flat D have shown that the radiation induced hardness increase is a function of both the neutron fluence and irradiation temperature in the range of 370 to 420°C. At a given temperature hardness increases with increasing fluence. On the other hand, for a given fluence, the hardness increase is greatest at the lower temperature. The most significant observation is that the temperature is a much more controlling variable in that a specimen irradiated to $1.2 \times 10^{22}$ n cm$^{-2}$ ($E_n > 1$ MeV) at 408°C shows a smaller increase in hardness than a specimen irradiated to only $5.8 \times 10^{21}$

n $cm^{-2}$ ($F_n > 1$ MeV) at 370°C. It has been demonstrated that multiple-stress type tests on a single specimen yield $\sigma$-$\epsilon$ relationships comparable to that obtained by running individual specimens at a constant load to failure. This correlation is obtained by utilizing the true stress concept rather than the applied stress based on the initial cross-sectional area and applied load. This technique is applicable to irradiated and unirradiated specimens as well, provided there are no irreversible stress or strain dependent changes in substructure. Transmission electron microscope studies on 304 SS after fatigue testing at 650°C and irradiation to $6.3 \times 10^{18}$ n $cm^{-2}$ ($E_n > 1$ MeV) at 70°C in the ORR show that the subgrain size is independent of whether or not the specimens are irradiated or unirradiated. The degree of subgrain boundary development depends both on precipitate distribution and irradiation. Transmission electron microscope studies have shown that the irradiation induced strength increase in molybdenum irradiated at 700 and 1000°C to $1.4 \times 10^{20}$ n $cm^{-2}$ ($E > 1$ MeV) and creep tested at 750°C can be attributed to the interaction of dislocations with voids (vacancy clusters). This hypothesis is in reasonable agreement with the dispersion barrier hardening model. The presence of voids in molybdenum and tungsten irradiated at $T > 0.31\ T_m$ is consistent with proposed temperature dependence of cavity nucleation. Also, it has been shown that the void size and density is lower for tungsten irradiated at the same neutron fluence and same homologous temperature as molybdenum. This is in agreement with what is expected from theoretical considerations due to the interaction of vacancies with the impurity atom rhenium generated from transmutations in tungsten. (auth)

**14812** (RD/B/N-1323) THE MEASUREMENT OF THE PRINCIPAL NEUTRON INDUCED RADIOACTIVITIES IN REACTOR GRADE TITANIUM METAL BY HIGH RESOLUTION Ge(Li) $\gamma$-RAY SPECTROMETRY. Reed, D.; Harvey, J. R. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs.). Oct 1969. 15p. Dep. CFSTI (U.S. Sales Only).

Component isotopes having both long and short half-lives arising from the Ti matrix by (n,$\gamma$) and (n,p) reactions, and from trace impurities by (n,$\gamma$) reactions, were measured after suitable decay periods. A mathematical expression is derived for the relative sensitivity of the 2 $cm^3$ planar detector to disc and cylindrical sources. This was used for the conversion of sample counting rates to disintegration rates. (auth) (UK)

**14813** (STI/PUB-230(Vol.1)) RADIATION DAMAGE IN REACTOR MATERIALS. VOLUME I. Proceedings Series. Proceedings of the Symposium Held in Vienna, 2-6 June 1969. (International Atomic Energy Agency, Vienna (Austria)). Nov 1969. 473p. (In several languages). (CONF-690620-(Vol.1)). IAEA $13.00.

Twenty six papers presented at the symposium are included in Vol. 1. A separate abstract was prepared for each of twenty four papers. Two papers were previously abstracted in NSA as 23: 41678 and 24: 4816. (J.R.D.)

*For abstracts of individual papers see: 14822-14842, 14910, 14995, and 14996.*

**14814** (STI/PUB-230(Vol.2)) RADIATION DAMAGE IN REACTOR MATERIALS. VOLUME II. Proceedings Series. Proceedings of the Symposium Held in Vienna, 2-6 June 1969. (International Atomic Energy Agency, Vienna (Austria)). Nov 1969. 615p. (In French and English). (CONF-690620-(Vol.2)). IAEA $17.00.

Thirty-one papers presented at the symposium are included in Vol. 2. A separate abstract was prepared for each of 28 papers. Three papers were previously abstracted in NSA as 23: 36269, 23: 39004, and 23: 48494. (J.R.D.)

*For abstracts of individual papers see: 14843-14860 and 14972-14981.*

**14815** ANELASTICITY IN COPPER AND ALUMINUM SUBJECTED TO NEUTRON IRRADIATION AND FATIGUE. Strible, Ferdinand Charles Jr. Los Angeles; Univ. of Southern California (1969). 326p.

Thesis.

A research investigation was made to study the phenomenology of fatigue and neutron irradiation in metals by correlating the effects of these phenomena with internal friction. Controlled experiments were conducted in which polycrystalline specimens of pure (99.999) copper and pure (99.989) aluminum were subjected to four known increments of fast neutron irradiation and were fatigued in rotating bending. At selected intervals, fatigue was interrupted to measure the internal friction in a torsion pendulum. Shortly before fatigue failure, internal friction was also measured at intervals of elevated temperature to investigate the effect of fatigue on thermally activated relaxation behavior. Fatigue was found to cause significant changes in the internal friction of both copper and aluminum. In unirradiated copper a sharp friction peak is initially formed and is followed by a rapid decline in friction to a minimum between 100 and 1000 cycles. The friction then increases until a plateau is reached where the friction temporarily stabilizes. After about 50% of the specimen life the friction moves out of the plateau and rises exponentially until failure. Neutron irradiation substantially reduces the internal friction of copper and minimizes the peak, trough, and plateau formations. Although the internal friction of irradiated copper increases during fatigue, it seldom attains the same value as that of the unirradiated copper at failure. The initial friction peak and trough formation in unirradiated copper is attributed to strain-generated dislocations which are quite mobile at first but rapidly cluster and tangle to cause fatigue hardening. After fatigue saturation is attained, slip zones begin to develop as dislocations pile up, side step barriers and congregate along planes of maximum shear. The friction plateau is interpreted as the completion of initial slip zone development and a period of localized damage progression. The exponential rise in friction following the plateau is attributed to enlargement of fatigue softened zones, development of microcracks and eventual microcrack linkup to form cracks of macroscopic size. The effect of neutron irradiation is to suppress the mobility of dislocations. Irradiation-generated defects, principally vacancies, migrate to dislocations to form effective pinning agents and thus reduce the length of dislocation loops. Dislocation pinning remains effective, in most instances, throughout the fatigue life. However the fatigue strength of copper is not greatly changed by irradiation which suggests that the reduced slip zone development is offset by increased stress concentrations at the irradiation-generated dislocation barriers. It is also probable that depleted zones formed by spikes and cascades are nuclei of microcrack development. In aluminum, fatigue causes the softened material to harden and the irradiation-hardened material to soften until the internal friction eventually converges to the same absolute value. Convergence occurs regardless of the amount of irradiation or the magnitude of the fatigue strain. Although irradiation initially reduces the room temperature friction by as much as 75% the irradiation-generated defects are relatively mobile and are more easily swept away during fatigue. The friction convergence readily explains the absence of any significant change in the fatigue strength of aluminum resulting from irradiation. Fatigue tends to suppress the magnitude of the grain boundary peaks of both copper and aluminum. The effect is attributed to the combination of increased background friction and peak broadening caused by an increased spectrum of relaxation times. Irradiation also tends to suppress the grain boundary peak in copper but has little effect on the grain boundary peak in aluminum. In copper the effects of irradiation and fatigue appear to be additive since the two phenomena together further suppress the grain boundary peak and, in some instances, essentially eliminate it altogether. (Diss. Abstr. Int., B)

**14816** OBSERVATION OF BUBBLES IN GAMMA-IRRADIATED LITHIUM HYDRIDE. Imai, T. (Univ. of California, Livermore). Phil. Mag.; 21: 281-6(Feb 1970).

Investigations with the electron microscope on $\gamma$-irradiated single crystals of LiH have revealed the presence of cubic voids or bubbles. These bubbles are crystallographically oriented, principally with their sides parallel to the (100) planes of the LiH crystals. Bubbles range in size from ~75 Å to ~1500 Å. Average bubble size increases with increasing irradiation dose and irradiation temperature, with temperature affecting size the most, by far. These bubbles are believed to be responsible for large swelling seen in irradiated LiH by Souers, Blake, Penpraze and Cline (1969). (auth) (UK)

**14817** RADIATION HARDENING EFFECTS IN ZIRCONIUM-BASE ALLOYS. Ray, S.; Sharma, B. D. (Bhabha Atomic Research Centre, Bombay). Trans. Indian Inst. Metals; 22: No. 2, 1-5(Jun 1969).

The comparative hardening effects in Zr-base alloys due to neutron irradiation is discussed. Investigations on Zr-0.5% Nb-1.0% Cr alloy have shown that Cr is a better stabilizer than Nb for radiation damage in Zr-base alloys. (auth)

**14818** FRACTURE TOUGHNESS OF BERYLLIUM. Harrod, D. L.; Hengstenberg, T. F.; Manjoine, M. J. (Westinghouse Electric Corp., Pittsburgh). J. Mater.; 4: 818-32(Sep 1969).

The concepts and methods of linear elastic sharp crack fracture mechanics were employed in the design and structural analysis of Be neutron reflectors used in the NERVA engine, requiring a knowledge of the fracture toughness of Be. The main objective of the study was to determine the opening mode plane-strain fracture toughness of S-200 grade Be in the temperature range -320°F to room temperature. Two different test specimen designs were employed, both crack-line loaded specimens: a WOL (wedge-opening-

loading) specimen and a DCB (double-cantilever-beam) specimen. Neutron irradiation tests were performed. The opening mode plane-strain fracture toughness tests of WOL specimens gave results about 35% higher than DCB. Below room temperature, the fracture toughness decreased approximately linearly with decreasing temperature. Fracture toughness was nearly isotropic, within about 10%, and appeared to be unaffected by loading rate for crosshead speeds up to 2 in./min. Heat treatments were found to have pronounced effects on fracture toughness. Neutron irradiation at −320°F caused a reduction of about 40% in fracture toughness at this temperature, but the damage could be annealed out at room temperature. (BBB)

**14819** ATOMIC CONFIGURATIONS OF DISPERSION CLUSTERS OF NEUTRON-IRRADIATED TUNGSTEN MONOCRYSTALS. Kukavadze, G. M.; Suvorov, A. L.; Sharov, B. V. Fiz. Metal. Metalloved.; 27: 797-9(May 1969). (In Russian).

The defects appearing in the crystalline lattice of tungsten during neutron irradiation (~$1.5 \times 10^{19}$) at 78°K were studied. The formation of individual vacancies which were shifted between the positions of atoms and small vacancy clusters with diameters up to 15 Å was discovered. (tr-auth)

**14820** STRUCTURE OF GAMMA-IRRADIATED METALS. Konozenko, I. D.; Krulikovskaya, M. P.; Zver'kov, L. S.; Popovich, N. N. (Inst. of Physics, Krasnoyarsk, USSR). Fiz. Metal. Metalloved.; 27: 861-4(May 1969). (In Russian).

Studies were made of the crystal structure of γ-irradiated aluminum, zinc, and iron alloys using x-ray and metallographic analyses. Conclusions were made concerning the radiation effects on the phase compositions. (tr-auth)

**14821** TEMPERATURE DEPENDENCE OF VOID FORMATION IN NEUTRON IRRADIATED NICKEL. Brimhall, J. L.; Mastel, B. (Battelle-Northwest, Richland, Wash.). Contract AT(45-1)-1830. Scr. Met.; 4: 51-4(Jan 1970).

The temperature dependence of void formation in irradiated nickel foil was investigated at 50 to 750°C. The nickel was irradiated with a fast neutron flux of $4.0$ to $6.2 \times 10^{19}$ n/cm$^2$. Data is given on the size, density, and volume fraction of the voids as a function of temperature. (G.M.C.)

**14822** RADIATION DAMAGE AND RECOVERY IN METALS. Nihoul, J. T. E. (SCK–CEN, Mol, Belg.). pp 3-31 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

The basic study of radiation damage in pure nonfissionable metals involves the production mechanisms of elementary defects such as vacancies and interstitials, their distribution, migration, interaction with each other and with other defects, and the mechanisms of annealing. The main types of basic irradiation experiments are reviewed. An outline of the present state of knowledge concerning the fundamental recovery mechanisms of defects in three important classes of metals, fcc, hcp, and bcc, is presented. The relative importance of the latter class may be justified by the important role of bcc metals in various technical applications, including reactor technology. (auth)

**14823** ANNEALING OF DEFECTS IN NEUTRON-IRRADIATED MOLYBDENUM: EFFECT OF EXTERNAL PRESSURES TO 70 kbar. Kulcinski, G. L.; Kissinger, H. E.; Mastel, B. (Battelle-Northwest, Richland, Wash.). pp 33-46 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

The effect of externally applied pressure on the annealing of neutron-induced radiation damage in high-purity molybdenum has been studied. Polycrystalline samples, irradiated to $6.2 \times 10^{18}$ n/cm$^2$ (E > 1 MeV) at a temperature of 40°C, were annealed for two hours at temperatures from 25 to 800°C and at pressures of 0, 10, 20, 30, 40, 50, 60 and 70 kbar. Lattice parameter measurements and transmission-electron-microscopy studies were conducted on each sample after each pressure-temperature treatment. The low-pressure, 0-kbar, studies revealed that the lattice parameter recovers in three distinct stages, 150, 400, and 750°C and that complete recovery occurs at 800°C. Annealing at higher pressures caused the recovery to occur at lower temperatures. For example, at 20 kbar the stage III (150°C) recovery was lowered to 90°C, and at 40 kbar it was lowered to room temperature (25°C). Furthermore, the temperature for complete lattice parameter recovery was lowered from 800°C at 0 kbar to 480°C at 10 kbar, 400°C at 20 kbar, 200°C at 40 kbar, 100°C at 60 kbar and 25°C at 70 kbar. Electron microscopy of the samples after the pressure-temperature anneals disclosed that the temperature for complete lattice parameter recovery corresponded approximately to the temperature at which the irradiation-produced interstitial clusters were completely removed. Accordingly, the temperature of interstitial cluster annealing is reduced as the applied pressure during the anneal is increased. At least two completely different processes are believed responsible for the pressure-induced healing of radiation damage in molybdenum. The lowering of stage III, a stage normally attributed to point defects, indicates that the responsible defect has a negative activation volume for migration. A negative value for this property reduces the activation enthalpy of migration, which in turn lowers the isochronal annealing temperature. On the other hand, the pressure-induced recovery of interstitial clusters appears to be connected with the intrinsic stability of defect clusters under stress and perhaps massive dislocation channelling effects. (auth)

**14824** DISLOCATION PINNING DURING RECOVERY AFTER FAST-NEUTRON IRRADIATION AT LOW TEMPERATURE. Okuda, S.; Nakanii, T. (Japan Atomic Energy Research Inst., Ibaraki). pp 47-59 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

The elastic modulus and internal friction of copper were measured during thermal annealings after fast-neutron irradiation at liquid helium temperature. Previous experiments were improved in technique and also extended to a higher dose of irradiation (≈$10^{17}$ n/cm$^2$, >0.1 MeV). The specimens were cold worked before irradiation to minimize a handling effect. During the stage-I recovery (below ≈55°K), elastic modulus increased. This increase was due to both dislocation pinning by stage-I defects and a bulk effect caused by annihilation of stage-I defects. Modulus defect due to a bulk effect was estimated to be less than 80%/at. % Frenkel defect. Dislocation pinning in stage I was substantiated by observations of changes in the amplitude dependent internal friction and height of the dislocation relaxation peak (N−W peak). Furthermore, suppression of dislocation motion by pinning, not by randomly distributed defects in the lattice, was seen to be dominant. During annealing above 100°K, modulus at 15°K increased continuously whereas modulus at 80°K decreased and the Bordoni peak grew continuously. To explain this result, a model of two types of pinning was presented and discussed. In the experiments, it was also shown that an appreciable amount of modulus defect due to dislocation motion at room temperature remained even after irradiation of ≈$10^{17}$ n/cm$^2$ because of dislocation de-pinning during thermal annealings. (auth)

**14825** SOME APPLICATIONS OF STRING EFFECT TO SOLID-STATE PHYSICS. Uggerhoej, E. (Univ. of Aarhus, Denmark). pp 89-95 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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The emission yield from single crystals doped with α- and β-emitters is envestigated. In the axis direction positrons and α-particles show pronounced dips whereas electrons show peaks. The magnitude of the dips and peaks is related to the damage in the crystal and to the percentage of emitting nuclei in lattice positions. The influence of annealing treatment is also discussed. (auth)

**14826** STUDY OF SMALL DEFECT CLUSTERS IN IRRADIATED MATERIALS BY MEANS OF TRANSMISSION ELECTRON MICROSCOPY. Ruehle, M. (Max-Planck-Institut fuer Metallforschung, Stuttgart). pp 113-58 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

The analysis of defect clusters in irradiated materials by means of transmission electron microscopy is reviewed. Calculations of the contrasts to be expected for several types of defects are considered including large dislocation loops, bubbles, clusters with displacement fields of spherical symmetry, small Frank-type dislocation loops, small perfect dislocation loops, tracks with displacement fields of cylindrical symmetry, and stacking-fault tetrahedra. From the results of the computations experimental methods for determining the nature of the defects are deduced. The reliability of the experimental results is critically discussed. Experimental results obtained on neutron-, electron-, ion-, and fission-fragment-irradiated materials are summarized. (auth)

**14827** DISPLACEMENT CASCADES IN GOLD BY MEANS OF TRANSMISSION ELECTRON MICROSCOPY. Merkle, K. L. (Argonne National Lab., Ill.). pp 159-70 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

The conditions have been investigated under which energetic displacement events will spontaneously form defect clusters that can be observed by transmission electron microscopy. The probability to form a cluster as well as the size distribution of the clusters is determined by the cascade energy. The energy distributions of those cascades that lead to the formation of visible clusters are compared with the size distributions of clusters in n, p, $\alpha$, and xenon irradiations. It is found that there is no fundamental difference in the cascade clusters produced by these different irradiations, but the numbers and sizes of clusters do reflect the numbers and energies of the cascades produced in any particular irradiation. At cascade energies above 30 to 40 keV there is a non-zero probability that two or more defect clusters are formed in a cascade. The arrangement of the multiple defects along some preferred crystallographic directions indicates that quasi-channeling plays a role in the splitting up into subcascades. A maximum diameter for single clusters of ≈200 Å was not exceeded in any of the irradiations. De-channeling of xenon at twin boundaries has been observed and can be used to study cascade clusters that are produced upon de-channeling in the vicinity of these boundaries. (auth)

**14828** DIRECT OBSERVATION OF RADIATION DAMAGE IN Al–$Al_2O_3$ ALLOYS. Ruedl, E. (EURATOM, Ispra, Italy). pp 171-83 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

Thin Al-foils containing a dispersion of 1 or 2.5 wt % $Al_2O_3$ were investigated by transmission electron microscopy. The foils were examined (a) as annealed, (b) annealed and neutron irradiated, (c) annealed and ion bombarded using oxygen, and (d) annealed and $\alpha$-particle bombarded. After annealing at 630°C a low density of dislocations is present in the foils. After irradiation at thermal neutron dose of ~$1.10^{20}$ n/cm² (~$10^{19}$ fast n/cm²) at 30°C no damage is visible in the foils neither in the Al-matrix nor within the particles. For medium to high doses of 9-keV oxygen bombardment, damage is formed in the bombarded surface of the foils which consists of clusters and straight dislocation lines, the latter being presumably misfit-dislocations. Whereas after the bombardment the clusters anneal out in the temperature range for Al self-diffusion, the misfit-dislocations are stable at higher temperatures. Bombardment of the foils with a high dose of alpha particles at 30 and 100°C leads to the formation of densely packed dislocations. This high dislocation density remains rather unchanged on subsequent annealing up to high temperatures while bubbles of ~100 Å diameter become visible on the dislocations. Only after annealing at ~660°C is a great reduction of the dislocation density and a significant growth of the bubbles observed. The bubbles being dragged by the dislocations become partly attached to the particles. The picture is different when the $\alpha$-bombardment is performed at 150°C. No dislocations are then observed but finely distributed bubbles of ~30 Å diameter are visible in the Al-matrix. A zone denuded of bubbles is present around the particles and small voids are observed on the particles. This indicates that helium has also precipitated at the particle/matrix interface. The bubbles grow slowly on annealing and partly move to the particle/matrix interface where large voids are being formed. (auth)

**14829** EFFECT OF ALLOYING AND COLD WORK ON THE NEUTRON IRRADIATION HARDENING OF METALS. Diehl, J.; Seidel, G. P. (Max-Planck-Institut fuer Metallforschung, Stuttgart). pp 187-214 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

A review is presented of the influence of alloying and cold work on the characteristics of neutron irradiation hardening in both fcc and bcc metals. The investigation of these influences is an initial approach to bridging the gap between fundamental studies on relatively pure and well-annealed metals on the one hand and actual reactor materials on the other. In the case of the fcc metals, copper is taken as a typical example. Radiation hardening in this material is examined as a function of pre-deformation, substitutional alloying, and the transition from single to polycrystals. For the bcc metals, emphasis is placed on the effect of interstitial impurities on the radiation hardening in single and polycrystals. The interstitial impurities carbon, nitrogen, and oxygen are found to have a strong influence on the hardening when mobile during irradiation. As an example, attention is focused on the characteristics of hardening in single crystalline and polycrystalline iron upon irradiation at normal reactor temperatures. (auth)

**14830** RADIATION HARDENING AND TRANSMISSION ELECTRON MICROSCOPY IN NIOBIUM. Tucker, R. P.; Ohr, S. M.; Wechsler, M. S. (Oak Ridge National Lab., Tenn.). pp 215-33 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

A brief review of radiation hardening and transmission electron microscopy (TEM) in niobium is presented. The dependence of the increase in yield stress upon neutron dose and defect cluster density and size distribution, dislocation channeling, radiation-anneal hardening, and the effect of radiation on the temperature dependence of the yield stress were investigated. Polycrystalline niobium tensile and TEM samples were neutron irradiated at reactor ambient temperatures to doses from 0.2 to $4.4 \times 10^{18}$ n/cm² (E > 1 MeV). When the density and size distribution of defect clusters observed by transmission electron microscopy is taken into account, the dose dependence of the yield stress at low doses is consistent with a planar dispersed barrier model corresponding to a barrier strength of (0.5 to 0.8) $Gb^2$, where G is the shear modulus and b is the Burgers vector. For doses above about $10^{18}$ n/cm², the hardening rate decreased sharply. The onset of this saturation effect occurs at doses at which dislocation channeling becomes prevalent. The crystal geometry of dislocation channels was studied. The plane of the dislocation channels was usually {100}. The strain in the channels was estimated from the offset in microstructural features and found to correspond to the passage of 1 to 3 slip dislocations per atomic slip plane. Upon post-irradiation annealing, the yield stress experienced an additional increase at 150 and 300°C. These radiation-anneal hardening peaks are attributed to the motion of oxygen and carbon, respectively, to the defect clusters, which is consistent with previous internal friction and resistivity measurements. From the density and size distribution of defect clusters in the radiation-anneal-hardened niobium, it is concluded that the defect clusters are strengthened upon annealing as barriers to dislocation motion by a factor of about two. Tensile tests from −180 to 25°C for samples irradiated to $3 \times 10^{17}$ n/cm² show that the increase in yield stress is approximately the same at all test temperatures, with perhaps a slight tendency for greater hardening at lower temperatures. It is concluded that the major factor contributing to radiation hardening in niobium is the short-range elastic interaction between radiation-produced defect clusters visible by TEM and dislocations set in motion upon deformation. (auth)

**14831** FACTORS AFFECTING THE BEHAVIOUR OF NEUTRON-IRRADIATED Ni-BASED AND Cu-Al ALLOYS AT ELEVATED TEMPERATURES. El-Shanshoury, I. A.; Voronin, I. M.; Gadallah, F. I.; Hammad, A. M.; Mohamed, H. G. (Atomic Energy Establishment, Cairo). pp 249-70 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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The effect of neutron irradiation on the behavior of irradiation-induced defects in Ni-based and Cu-Al alloys at elevated temperatures was investigated. Irradiation produces changes in the mechanical properties with subsequent recovery at elevated temperatures. At temperatures higher than those of the recovery appreciable differences in elongation to fracture and grain size of the irradiated and unirradiated alloys were observed. A linear relationship between the drop in ductilities and the thermal neutron integrated doses was found at the temperature range 600 to 900°C. The differences in ductilities and in grain growth of the irradiated and unirradiated materials were explained by the presence of helium and/or lithium atoms generated through the $^{10}B(n, \alpha)^7Li$ reaction. Specimens with different grain sizes produce the same effect on the difference in the magnitude of drop in ductilities between 400 to 800°C for irradiated and unirradiated alloys. The magnitude of the drop in ductility and the temperatures at which the alloys lose their ductility were found to fall with a decrease in extension rate for irradiated and unirradiated Ni-based alloys. A shift of about 60°C is obtained with a change in the extension rates from 80 to 2.5 or from 2.5 to 0.1 mm/min for unirradiated and irradiated materials. Irradiation increases the tempera-

ture range of the minimum ductility by about 200°C. The effect of extension rates on the mechanical properties was explained by the direct relation between the strain rate and the diffusion of vacancies to cracks or fissures produced by helium bubbles which are responsible for the observed loss in the properties. Plastic deformation of irradiated Cu-Al alloys was found to stabilize radiation-induced defects and shift the recovery temperature to a higher value. No annihilation of radiation defects was observed after the deformation of the alloys. A tentative model based on the interaction of edge dislocations introduced during plastic deformation and Seeger's zones is represented to explain the stabilization process. (auth)

**14832** HARDENING OF PURE IRON BY NEUTRON IRRADIATION. Malkin, J. (CEN, Saclay, France). pp 271-87 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969). (In French).

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The degree of brittleness of reactor vessel steel is directly related to the ability of the metal to relax, by means of plastic deformation, any local static or dynamic excess pressure (particularly in the vicinity of a crack). The kinetics of the relaxation are related to the yield point of the metal and to the kinetics of the dislocations which occur during plastic flow. It is thus very important to understand the way in which these parameters are modified by irradiation and in particular to know whether the defects induced by irradiation result in thermal hardening or not. For a study of hardening it is necessary to measure the volume of activation of the slip mechanism and its development after irradiation. The technique of relaxation allows acquisition of information on the density of mobile dislocations and on the laws of kinetics. The results of experiments conducted with pure iron irradiated up to $3 \times 10^{19}$ n/cm$^2$ (E > 1 MeV) are presented. In pure iron, irradiation results in large obstacles (a cluster of pinhole defects) which give rise to athermal hardening, and small obstacles, the nature of which is not defined, which give rise to slight thermal hardening. The latter type of hardening is interpreted as the superimposing on the hardening due to the lattice (Peierls mechanism) the hardening by elastic interaction between the screw dislocations and small tetragonal distortions due to irradiation defects (Fleischer mechanism). (auth)

**14833** RADIATION DAMAGE AND THERMAL ANNEALING OF DEFECTS IN MOLYBDENUM AND TUNGSTEN. Ivanov, A. N.; Elesin, L. A.; Pravdyuk, N. F. (Inst. of Atomic Energy, Moscow). pp 289-301 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969). (In Russian).

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Radiation damage to high-temperature metal homologues of molybdenum and tungsten as a function of dose ($10^{18}$ to $10^{21}$ fast neutrons/cm$^2$; E > 1 MeV) and the reactor irradiation temperature is investigated. The studies were conducted with polycrystalline specimens 99.9% pure in the case of molybdenum and 99.85% in the case of tungsten. Variation in the specific electric-resistance was used as a measure of the radiation damage. The saturation effect of the radiation damage and the differences observed between the behavior of molybdenum and tungsten are discussed from the standpoint of the thermal stability of the radiation defects formed in them. The part played by radiation alloying when tungsten is irradiated with large thermal neutron doses is also discussed. A study is made of the thermal annealing of radiation defects in molybdenum and tungsten subjected to various irradiation doses at temperatures above room temperature. The similarity between the three recovery stages in the increase in specific electric-resistance, observed during annealing in these metals, and the nature of the defects responsible for the recovery stages are discussed. The variation in fine crystal structure for molybdenum and tungsten during reactor irradiation and subsequent annealing is investigated using electron microscopy with transmitted light and x-ray diffraction. (auth)

**14834** HELIUM EMBRITTLEMENT OF FUEL-CLADDING ALLOYS FOR POTENTIAL SERVICE IN FAST-BREEDER REACTORS. Kramer, D.; Garr, K. R.; Rhodes, C. G.; Pard, A. G. (Atomics International, Canoga Park, Calif.). Contract AT(04-3)-701. pp 303-14 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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Helium was injected into small sheet tensile samples of Types 304, 304L, and 316 stainless steels, Incoloy 800 (all four austenitic), Types 405 stainless steel (ferritic), IN-102 and Inconel 625 (both nickel base), and 19-9DL (iron base), by $\alpha$-particle irradiation from a cyclotron to concentrations up to $4 \times 10^{-5}$ atom fraction. Thus, helium concentrations, equivalent to those expected after several years of service in a fast-breeder reactor, were produced in less than a day. Ductility losses were observed for all the alloys during tensile tests between 500 and 800°C; Type 405 stainless steel and 19-9DL retained significantly more ductility at 700°C than the other alloys. Helium decreased the rupture time and elongation of Types 304 and 316 stainless steels stress-rupture at 760 and 700°C, respectively. A helium concentration of only $1 \times 10^{-6}$ atom fraction reduced the rupture time of Type 304 stainless steel by 40%. Loss of ductility during tensile testing was always accompanied by partial or complete intergranular failure, whereas failures were usually transgranular in the absence of helium. During plastic deformation at high temperatures, moving dislocations sweep helium, in the form of small bubbles or clusters, to the grain boundaries upon which they are constrained to move. Agglomeration of the helium into large bubbles, and subsequent growth, takes place on the grain boundaries, particularly where they intersect precipitates such as carbides. Helium bubbles up to 1000 Å in length were seen attached to these precipitates. Grain-boundary cracks were observed to originate at carbide particles owing to their obstruction of grain-boundary sliding in the absence of helium. The presence of helium, in the form of bubbles attached to grain-boundary carbide particles, promotes grain-boundary cracking by reducing the amount of sliding necessary to nucleate a crack. Propagation of cracks is aided by the presence of other helium bubbles on the grain boundary. During long-time stress-rupture tests, stress-induced bubble growth assumes more importance in the mechanism of failure. The effect of helium may be reduced by the presence of a fine dispersion of precipitates within the grains capable of trapping helium bubbles, a microstructure in which simple grain-boundary sliding is restricted, and an ultra-fine grain size. (auth)

**14835** EVALUATION BY LINEAR ELASTIC FRACTURE MECHANICS OF RADIATION DAMAGE TO PRESSURE-VESSEL STEELS. Mager, T. R.; Hazelton, W. S. (Westinghouse Electric Corp., Pittsburgh). pp 317-32 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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The ability of a pressure-vessel steel to resist fracture constitutes an important factor in ensuring nuclear reactor safety. The hardening and embrittlement of mild steels are important in connection with the safety of reactor pressure vessels. Present design against brittle fracture of pressure vessels for nuclear power plants is based on the transition temperature approach. However, in the last several years, a much more sophisticated and quantitative approach to the brittle fracture problem has been developed. The fracture mechanics or crack toughness approach provides quantitative data to assess the potential of brittle failures and in developing criteria for designing against failure for the life of a nuclear pressure vessel. Experimental testing of a group of reactor vessel steels, utilizing both the Wedge Opening Loading (WOL) specimen and the Compact $K_{Ic}$ specimen, was performed to investigate the application of the fracture mechanics technique to these materials in both the non-irradiated and irradiated conditions. Materials investigated included base metal from a heat of ASTM A533, grade B, class I steel, weld metal from a heat of ASTM A533, grade B, class I steel, and the base metal from a European forging-grade steel. Tensiles and Charpy-V-notch specimens from these materials were also included in the program to provide correlation data. The fracture toughness of the various vessel materials was determined by measurement of $K_{Ic}$, the critical stress intensity factor, which is considered to be a basic material property. Using the fracture mechanics approach and considering irradiation effects, allowable defect size was calculated and compared with the present transition temperature criteria. The fracture toughness of the irradiated pressure-vessel steels is compared with the fracture toughness of the non-irradiated material. The net change in tensile properties, as well as the shift in NDT based on Charpy-V notch specimens, is reported. The irradiation portion of the experiment was performed at 550°F, subjecting the specimens to a total exposure of 3 to $4 \times 10^{19}$ n/cm$^2$. (auth)

**14836** IRRADIATION EMBRITTLEMENT OF A LOW-ALLOY STEEL HEAT TREATED TO DIFFERENT MICROSTRUCTURES. Vacek, M. (Inst. of Nuclear Research, Rez, Czech.); Vrtel, J. pp 333-49 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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The effect of martensite and bainite microstructures in untempered and tempered states, as well as ferrite-perlite microstructure on the irradiation hardening and embrittlement of a low-alloy Mn-Ni-Cr-Mo-Nb-fine-grained reactor pressure-vessel steel, was investigated. The cylindrical miniature tensile and impact specimens were irradiated at 65°C to a time integral of neutron flux density up to $1 \times 10^{19}$ n/cm$^2$. The specimens were prepared from a 190-mm plate and heat-treated to the desired microstructure conditions. The irradiation and testing conditions were identical for all microstructures. The tensile tests were performed on a modified cryostat of the Instron testing machine from room temperature to -196°C. The results were analyzed by plotting the fracture stress, yield stress, and reduction of area at fracture as a function of temperature. The impact specimens were also tested as a function of temperature, and the impact-energy transition temperature was determined. The radiation hardening manifested in changes of yield stress and the radiation embrittlement expressed by the impact-energy transition temperature were correlated. Thus it was possible to range the microstructures according to the distance below the notch, where cleavage fracture starts, i.e., according to the dimensions of the plastic zone accompanying the fracture. The best combination of strength properties and toughness was achieved for low-carbon martensite tempered to high temperature. (auth)

**14837** NEUTRON EMBRITTLEMENT AND DAMAGE RELIEF OF THE BR3/VULCAIN PRESSURE-VESSEL STEEL. De Meester, P. J. A. (Catholic Univ. of Louvain, Belg.); Van Asbroeck, Ph. pp 351-63 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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A302B pressure-vessel steel specimens were irradiated at various temperatures and fluence up to $8.5 \times 10^{20}$ n/cm$^2$ (> 1 MeV) in the BR3 and modified BR3/VULCAIN reactor. Tensile and impact tests, hardness measurements, and micrographical examination were performed after irradiation. Results agree with the observed trend in NDT shift and tensile strength as well as hardness increase. Furthermore, annealing of some specimens irradiated at $2.2 \times 10^{20}$ n/cm$^2$ shows that most of the damage can be relieved after 72 hr at 400°C; however, the same annealing procedure only yielded a restoration of about 20% for specimens irradiated at $8.5 \times 10^{20}$ n/cm$^2$. A tentative explanation of these phenomena and measurements is given in terms of micro-metallurgical aspects of this type of steel. (auth)

**14838** IRRADIATION GROWTH AND CREEP IN ZIRCALOY-2. Hesketh, R. V.; Harbottle, J. E.; Waterman, N. A.; Lobb, R. C. (Berkeley Nuclear Labs., Eng.). pp 365-83 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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The irradiation growth coefficient, G, of Zircaloy-2, under fast-neutron bombardment, has been measured at 40 and 280°C over a range of fission neutron fluence from $2 \times 10^{21}$ m$^{-2}$ to $1 \times 10^{24}$ m$^{-2}$. Isolated results for 78°K, 80, 160 and 230°C are also given. At 40°C the accuracy of measurement is better than 5%. The growth coefficient decreases from >10 to ~1; its dependence on neutron fluence, $\phi t$, is $(\phi t)^{-\frac{1}{2}}$ at 280°C, while at 40°C the dependence falls from $(\phi t)^{-\frac{1}{2}}$ or $(\phi t)^{-\frac{1}{3}}$. Growth at 280°C is less than 40°C, and the index could be simply a function of the growth strain. The dimensional change due to the change of shape exceeds by a factor of 4 that due to the decrease in density; at $\phi t = 10^{23}$ m$^{-2}$, $\Delta\rho \leq 3 \times 10^{-4}$ $\rho_0$. The initially high value of G explains the rapid onset of irradiation creep. The measured value of G at fission neutron fluences of $10^{23}$ to $10^{24}$ m$^{-2}$ agrees with that deduced from irradiation creep. It is shown that reported discrepancies between sets of creep data are apparent rather than real. (auth)

**14839** THEORETICAL AND EXPERIMENTAL INVESTIGATIONS INTO HIGH-TEMPERATURE EMBRITTLEMENT OF HIGH-TEMPERATURE STEELS. Reiff, K. H. (Siemens Aktiengesellschaft, Erlangen, Ger.). pp 401-15 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

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A model of a gas-filled wedge-type crack was developed analogously to the gas-filled bubble. In cases where fracture of the specimen is accompanied by the formation of long, pointed wedge-type cracks, this model should be preferred to the bubble model, since it corresponds more closely to the optical picture of the fracture. The influence of various material parameters on high-temperature irradiation embrittlement is described with the aid of the model of the gas-filled wedge-type crack. It is shown how the properties of Federal German steels No. 4961 (16 Cr/13 Ni/Nb) and No. 4981 (16 Cr/16 Ni/MoNb) can be improved considerably regarding ductility, especially in the irradiated state. This improvement is also remarkable in that it is accompanied by an increase in the long-time creep resistance. (auth)

**14840** RADIATION CREEP IN URANIUM AND GRAPHITE. Platonov, P. A.; Dubrovin, K. P.; Karpukhin, V. I.; Virgil'ev, Yu. S. (Inst. of Atomic Energy, Moscow). pp 417-28 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969). (In Russian).

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The results of a study of creep and stress relaxation are presented for $\alpha$-uranium and a uranium alloy containing 9% molybdenum both in the homogeneous and heterogeneous states when irradiated at temperatures between 60 and 100°C with a thermal neutron flux of $5 \times 10^{12}$-$10^{13}$ n/cm$^2$ sec. It is demonstrated that the radiation creep curves for $\alpha$- and $\gamma$-uranium are different, creep in $\alpha$-uranium being characterized by both transition and steady-state stages, whereas the study of $\gamma$-uranium creep only reveals the transition stage. The creep rate for both the transition and steady-state stages is proportional to the applied stress. Comparison of creep and stress relaxation data indicates that there is a definite correlation between these two effects. Results of creep tests with polycrystalline reactor graphite when irradiated in a reactor at temperatures between 100 and 900°C over an integral neutron flux range of $10^{20}$ to $10^{21}$ n/cm$^2$ are described. An analysis of the results show that for graphite as well as $\alpha$-uranium both the creep stages are present; the creep rate is proportional to the applied stress and in the non-steady state the creep is described both for uranium and graphite by an almost logarithmic relationship that is a function of the radiation dose. Steady-state creep in graphite varies with temperature, the minimum value occurring at about 500°C. The creep data are discussed and the non-steady-state creep is explained by diffusional migration of the dislocations due to a flux of excess radiation defects, while the steady-state creep data are discussed in terms of Cottrell's radiation creep theory. The experimental results show that the creep component created by the anisotropic increase in radiation both for uranium and graphite makes the basic contribution to steady-state creep in steels. (auth)

**14841** ROLE OF IN-PILE IRRADIATION IN PRODUCING HIGH-TEMPERATURE BRITTLENESS IN STEELS. Balashov, V. D.; Votinov, S. N.; Grinchuk, P. P.; Ostrovskii, Z. E.; Prokhorov, V. I.; Shamardin, V. K. (Scientific-Research Inst. of Atomic Reactors, Melekess, USSR). pp 429-56 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969). (In Russian).

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The results are given of an investigation into the effect of in-pile irradiation on the mechanical properties and structure of alloys of the Fe-Cr-Ni$_x$ system and austenitic and ferritic stainless steels. Irradiation of the materials was carried out in the core of the SM-2 reactor at temperatures of 70, 350, and 650 to 700°C and in the dose range from $2 \times 10^{20}$ to $2 \times 10^{22}$ n/cm$^2$ ($E \geq 1$ MeV). After irradiation the mechanical characteristics of samples were determined in the temperature range 20 to 800°C, and the structure was analyzed. It was established that all the materials studied (including chromium steels) are subject to a reduction in plasticity at high temperatures. The extent of the reduction and the temperature region in which the effect is observed are substantially different, however, for steels and alloys of the same base but alloyed differently. Steels of the 16-15 type with an additional admixture of molybdenum and boron are least affected by irradiation. These steels undergo practically no radiation embrittlement up to a temperature of 700 to 750°C. It is noted that nickel-base dispersion-hardening steels and alloys are subject to the greatest degree of embrittlement. Analysis results show that the chief reason for high-temperature radiation embrittlement is the process of radiation aging. The wide range of materials studied makes it possible to set them out in tabular form in such a way as to allow prediction of the high-temperature properties of various iron-chromium-nickel steels and alloys under the effect of irradiation, on the basis of their chemical composition. (auth)

**14842** LONG-TERM STABILITY AND CREEP OF IRRADIATED ALUMINUM. Ilyasov, V. M.; Votinov, S. N.; Betekhtin, V. I. (Scientific-Research Inst. of Atomic Reactors, Melekess, USSR). pp 457-64 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969). (In Russian).

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The influence of neutron irradiation ($10^{22}$ n/cm$^2$, E > 1 MeV, T ≈ 50°C) on the long-term stability and creep of aluminum of varying purity was investigated. Flat aluminum samples were subjected to monoaxial tension and then left to lie out for several months after irradiation. It was found that in the case of irradiated aluminum the relations between long-term stability and stationary creep rate on the one-hand and breaking stress and experimental temperature on the other can be described by general equations. Analysis of the parameters of these equations showed that the substantial increase observed in long-term stability and the decrease in creep rate after irradiation are not associated with a change in the breakdown mechanism and in its kinetic, thermal-fluctuation character, but are due to the structural effects of irradiation. The degree of radiation hardening was found to be greater in the purer (and less stable) aluminum. The total expansion after irradiation decreased by a factor of two. (auth)

**14843** COMPUTER EXPERIMENTS TO PREDICT RADIATION EFFECTS IN REACTOR MATERIALS. Beeler, J. R. Jr. (North Carolina State Univ., Raleigh). pp 3-31 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

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Use of the computer experiment technique to predict the different radiation effects, which are produced in a given reactor material when subjected to different irradiation conditions, is reviewed. Computer experiment methods for simulating radiation damage production and annealing in metals and alloys, in a crystal lattice at the level of atomic dimensions, are illustrated and critically discussed. The degree to which the density and microscopic distribution of damage predicted by computer experiments agree with direct, field ion microscope observations is then considered. In this regard, both the primary and annealed damage states are considered. In addition the use of computer experiment techniques to extrapolate from experimental radiation effects data obtained for irradiations in several existing reactors, to predict those which should be most probable in a given design-board reactor, is discussed. The review covers: (1) computation of the primary knock-on atom density and energy spectrum as a function of sample size, sample composition, and neutron energy spectrum; (2) simulation of atomic collision cascades initiated by primary knock-on atoms; (3) annealing of the displacement spike and/or other damage produced by a collision cascade; (4) saturation effects caused by the overlapping of collision cascade damage regions; (5) void nucleation and growth; (6) effects of impurity atoms on damage annealing; (7) effects of internal boundaries on damage production and annealing. The computation of the stress required to move a dislocation through a damaged region by simulation of dislocation movement through a field of obstacles is illustrated. Particular emphasis is placed upon the use of empirical data from various sub-fields of physics, chemistry, and metallurgy as the foundation for describing defect interactions in radiation damage and annealing computer experiments. When this empirical approach is adopted, the scope of the computer experiment technique is considerably enlarged, for it then becomes a technique for combining the presently known experimental data, in a logically self-consistent way, to predict radiation effects in reactor materials on a relatively direct basis. (auth)

**14844** DAMAGE-FUNCTION ANALYSIS OF NEUTRON-ENERGY AND SPECTRUM EFFECTS UPON THE RADIATION EMBRITTLEMENT OF STEELS. Serpan, C. Z. Jr. (Naval Research Lab., Washington, D. C.); McElroy, W. N. pp 33-51 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

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Critical evaluations of irradiation effects data for steels exposed in different reactor environments depend upon fluence measurements that reflect the neutron population and the corresponding influence of damage mechanisms inherent to those neutron energy spectra. Theoretical models describing neutron damage in reactors were adjusted with data on mechanical property changes of A302-B steel irradiated at <450°F. This procedure yielded a damage function more properly accounting for the energy dependence of damage. The investigation centered on a new comprehensive experiment which yielded wide variations in spectra and corresponding measures of neutron embrittlement. The performance of the experiment and the resultant data have validated the damage function. An important new part of the damage function analysis technique provides the per cent contributions of neutrons of all energy levels to the embrittlement process. Values of the damage function, averaged for a typical reactor physics spectral calculation group structure, are presented with suitable description of their application to a wide variety of spectra. One major conclusion reached is that detailed as well as accurate neutron dosimetry measurements of fast and thermal fluxes, corrected to reactor operating temperatures, are necessary if good correlations among irradiation effects data are to be obtained. This requirement applies to both experimental irradiations and to irradiations at reactor component surveillance locations. It was also found that an independently derived damage function for irradiation of structural steels such as A302-B at <450°F is realistic and can be applied to new experimental data conforming to those conditions. The contribution of thermal and low-energy neutrons to the embrittlement process in low-alloy steel is shown to be of major importance to the interpretation of radiation effects data. (auth)

**14845** EFFECT OF FLUX SPECTRUM ON IRRADIATION DAMAGE AND SAFETY ANALYSES OF THE HBWR PRESSURE VESSEL. Hanevik, A.; Videm, K. (Institut for Atomenergi, Kjeller, Norway). pp 53-65 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

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The impact properties of the mild steel components in the Halden Boiling Water Reactor (HBWR) have been investigated by irradiation of Charpy V-notch impact specimens in LITR and in two different flux spectra in HBWR. The neutron spectra at the irradiation positions in HBWR have been calculated by three different computer codes and the results checked by irradiation of threshold detectors. The irradiation-induced changes in transition temperatures were found to be larger in the HBWR experiments than in those performed in LITR for comparable fluences of neutrons with energy above 1 MeV due to different spectra in the two reactors. In assessment of the results use is made of a multigroup damage cross-section model. The experimental results are in close agreement with the calculated values. The experimental results have been used for assessment of the transition temperatures of the HBWR pressure vessel at various stages of operation. A brittle-fracture analysis is presented based on the elasto-plastic approach. The safe minimum temperature under shut-down conditions of the HBWR vessel at the end of the present 3rd charge operation is found to be 19°C. Fast fracture at operating conditions is not credible before the HBWR has experienced about 520 major power cycles. (auth)

**14846** CALCULATION AND EXPERIMENTAL METHOD FOR CORRELATING THE RADIATION ENERGY BETWEEN HEATING AND DISPLACED ATOMS. Navalkar, M. P.; Ramakrishna, D. V. S. (Bhabha Atomic Research Centre, Trombay, India). pp 145-53 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

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It is known that a sample exposed to reactor radiation absorbs energy which manifests itself as heat. It is generally assumed that all the energy deposited appears as heat. This, however, may not be strictly true and depends on the Z number of the sample as part of the energy is spent in producing displaced atoms. Preliminary calculations have been done with various materials to find the ratio of the energy spent in producing displaced atoms which does not appear as heat to the total energy for various reactor spectra characterized by spectral parameters such as $\beta$ and $\mu$. To test the results of the calculations, an experiment has been suggested. By studying heating rate in samples of different Z numbers, it is possible to separate out the fast-neutron contribution from the total. The experimental heating rate due to fast neutrons can then be compared with the estimated heating rate to verify the results of the calculations. (auth)

**14847** VOID FORMATION IN STAINLESS STEEL DURING CHARGED-PARTICLE IRRADIATION AT ELEVATED TEMPERATURES. Nelson, R. S.; Mazey, D. J. (Atomic Energy Research Establishment, Harwell, Eng.). pp 157-63 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

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It is now well established that voids are formed in stainless steel after prolonged irradiation with fast neutrons at certain elevated temperatures. However, the precise mechanism by which such voids are formed has been opened to speculation, particularly from the point of view of the importance of the helium and hydrogen which is inevitably produced as a consequence of transmutation. In such reactor irradiations it is virtually impossible to isolate the individual effects of radiation damage and of helium and hydrogen. Furthermore it is difficult and time consuming to perform irradiations to high neutron doses at different dose rates and at accurately controlled temperatures. However, in principle the limitations can be overcome by simulating the effects using particle accelerators. A series of experiments using the Harwell 150-keV Heavy Ion Accelerator which have been successful in producing voids in type 316 steel is described. The relative importance of helium and radiation damage is discussed together with the current theories on void formation. (auth)

**14848** FAST-REACTOR RADIATION-INDUCED CHANGES IN CLADDING AND STRUCTURAL MATERIALS. Claudson, T. T.; Holmes, J. J.; Straalsund, J. L.; Brager, H. R. (Battelle-Northwest, Richland, Wash.). pp 165-87 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

The radiation-produced volume change in cladding and structural materials in terms of the relations between neutron fluence, irradiation temperature and swelling, nucleation and growth kinetics of voids, microstructural changes which are responsible for swelling, and possible methods for controlling swelling are discussed. The data described are primarily related to type 304 stainless steel irradiated in the EBR-II over a range of fluence levels to $9 \times 10^{22}$ n/cm$^2$ (E > 0.1 MeV). Irradiation temperatures between 370 and 460°C are prevalent. The flux, fluence, and temperature dependence of swelling in 304 stainless steel has been found, by density measurements, to follow the expression $\Delta V/V_f = 6 \times 10^{-34}(\phi t)^{1.8} \exp - 10{,}200/RT$ where $\Delta V/V_f$ is the increase in volume divided by the final volume and $\phi t$ is the fast-neutron fluence (n/cm$^2$). Transmission-electron microscopy results indicate that the as-irradiated density change may be accounted for by the total volume of voids observed in the microstructure. The amount and size distribution of the voids depends upon the irradiation temperature and fluence, the average void radius increasing with irradiation temperature and fluence. The void density increases with flux and decreases with increasing temperature. The size and density of interstitial loops appear to follow a similar trend. Void formation is considered to be due to the agglomeration of excess vacancies created by irradiation. Several mechanisms for growth by vacancy absorption processes are considered and all are found to predict greater fluence dependence than actually observed. These mechanisms are the basis for void size distribution predictions which differ greatly from transmission-electron microscopy results. It is shown that effects such as interstitial loop-void interactions must be considered to develop a kinetic model consistent with both observed microstructure and macroscopic density changes. The importance of void-loop interactions and other damage mechanisms suggests means by which swelling in fast-reactor materials can be controlled through metallurgical alloying and processing procedures. (auth)

**14849** A MODEL FOR VOID FORMATION IN METALS IRRADIATED IN A FAST-NEUTRON ENVIRONMENT. Harkness, S. D.; Li, Che-yu (Argonne National Lab., Ill.). pp 189-214 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

Experimental observations on voids formed in fast-neutron-irradiated, Type 304 stainless steel are presented. The irradiated microstructure is characterized by a homogeneous distribution of polyhedral voids and Frank dislocation loops. The number densities for each species were about $10^{15}$/cm$^3$ while the defects ranged in size up to several hundred angstroms. Neither of these defects, however, was seen to form at grain boundaries. The temperature dependence of void formation is discussed in terms of observations on three samples receiving about the same neutron exposure at 375, 460, and 600°C. No voids were observed to form at 600°C while void formation increased between the 375 and 460°C irradiation temperatures. An exponential dependence of void formation and neutron exposure was also noted. A model to explain these experimental observations has been developed. The model is based on using the concepts of nucleation and growth theory to determine the temperature dependence of the nucleation and growth rates. These results were incorporated into a Johnson-Mehl type expression to determine a theoretical temperature dependence for void formation. It was found that good agreement with experimental results could be attained if it is assumed that the nucleation sites for void formation were the small vacancy clusters formed at the core of displacement sites and that the growth rate was size dependent. The expression for void volume fraction involves $\phi$, the neutron flux; $E_m$, the vacancy energy of motion; $N_v$, the steady-state vacancy concentration; $\gamma$, the surface energy; $D_v$, the vacancy diffusion coefficient; T, the absolute temperature; and t, the irradiation time. The expression for void volume fraction is

$$V_F = 1 - \exp\left[-.0369\,\phi \exp\left(-\frac{E_M}{RT}\right) \exp\left(\frac{-16\pi\gamma^3}{3RT(RT\ln\frac{N_v}{N_{vo}})^2}\right)(D_v N_v)^{3/4} t^{3/4}\right].$$

The constant in this expression was evaluated by comparison with experimental results. Results of this approach indicated that void formation was most sensitive to changes in the energies of vacancy formation and motion and the surface energy of the material. A decrease in the vacancy energy of formation resulted in a decrease in the amount of void formation as well as a shift in its occurrence to lower temperatures. Results of model analyses indicated an increase in the vacancy energy of motion should decrease the amount of void formation while shifting its occurrence to higher temperatures. Analytical results also indicated that increasing the surface energy of the material resulted in a decrease in the amount of void formation and a shift in its occurrence to lower temperatures. It is suggested that the presence of helium atoms was important to the nucleation of voids in stainless steel due to the fact that the void is a high-energy form in austenitic stainless steel relative to planar defects. It is also suggested that void stabilization by gas atoms may not be necessary in materials such as nickel where the void is a low energy form. (auth)

**14850** HIGH-FLUENCE NEUTRON-IRRADIATION DAMAGE IN ALUMINUM. Stiegler, J. O.; Farrell, K.; Dubose, C. K. H.; King, R. T. (Oak Ridge National Lab., Tenn.). pp 215-32 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

Structural damage occurring in 99.9999% aluminum and in commercial aluminum of 99% purity as a result of high-fluence neutron irradiation has been examined by means of transmission electron microscopy. Both displacement damage and impurities produced by nuclear transmutations were observed. In the high-purity aluminum, octahedral voids and many dislocations loops were created by a fast fluence of $3.5 \times 10^{20}$ n/cm$^2$ (E > 0.82 MeV) at 50°C. A contrast analysis of some of the larger loops showed them to be vacancy type. The distribution of the voids and loops was non-uniform, areas containing large voids usually having small loops and vice versa, suggesting that most of the loops were probably of vacancy character. The heterogeneous disposition of the voids is interpreted in terms of an association of voids with dissolved impurities. The only radiation damage observed in the commercial purity aluminum after exposure to $3.5 \times 10^{20}$ n/cm$^2$ at 50°C was a few prismatic dislocation loops around grown-in dislocations; loops of both vacancy and interstitial types were identified. Commercial purity material irradiated to fast and thermal fluences in excess of $10^{22}$ n/cm$^2$ at 45°C contained a uniform distribution of cubic voids and dislocations and a fine precipitate of silicon. Post-irradiation annealing caused the voids to disappear at a temperature in the range 230 to 315°C, and the silicon precipitate in the highly irradiated impure aluminum coarsened markedly. Annealing at 455°C caused gas bubbles to form on grain boundaries and dislocations in the heavily irradiated impure aluminum. (auth)

**14851** GROWTH, STABILITY, AND INTERACTIONS OF VOIDS AND GAS BUBBLES IN SOLIDS. Bullough, R.; Perrin, R. C. (Atomic Energy Research Establishment, Harwell, Eng.). pp 233-51 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

An atomic model consisting of a large parallepiped of freely interacting atoms has been constructed to simulate bcc iron. A

new, non-equilibrium, interatomic potential which includes first, second and third neighbor interactions, has been constructed by accurate fitting to the available phonon dispersion data. This model has been used to investigate the growth and stability of vacancy aggregates. The conditions under which such an aggregate will adopt a collapsed morphology is discussed in relation to the presence of small quantities of gas in the void nuclei. The exact interaction between two finite gas bubbles with arbitrary associated excess gas pressures has recently been calculated using an isotropic elastic continuum model. The significance of this interaction to the growth of voids by the accretion of vacancies is discussed and related to the problem of voidage formation in cladding materials. (auth)

**14852** EFFECT OF IRRADIATION ON NICKEL AND IRON–NICKEL ALLOYS. Bilger, H.; Bourret, A.; Chambron, W.; Chamberod, A.; Dautreppe, D.; Minier, C.; Moser, P.; Pauleve, J.; Peretto, P. (CEN, Grenoble, France). pp 259-67 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB–230(Vol.2); CONF-690620–(Vol.2).

Results of a basic study of irradiation defects in pure nickel and in iron-nickel alloys are presented. Special attention is paid to the nature of the defects responsible for the different stages in annealing of the physical properties and the difference in the interstitial agglomeration processes as between pure nickel and iron-nickel alloy (50%-50%). (auth)

**14853** INFLUENCE OF IRRADIATION TEMPERATURE ON THE CREEP-RUPTURE PROPERTIES OF POLYCRYSTALLINE MOLYBDENUM. Moteff, J.; Rau, R. C.; Kingsbury, F. D. (General Electric Co., Cincinnati). Contract AT(40-1)-2847. pp 269-81 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB–230(Vol.2); CONF-690620–(Vol.2).

The effects of irradiation temperature on the post-irradiation creep-rupture properties of recrystallized molybdenum has been investigated. Specimens were irradiated at 70, 700, and 1000°C to fast-neutron fluences of about $1.4 \times 10^{20}$ n cm$^{-2}$ (E > 1 MeV), and subsequently creep-rupture tested at a temperature of 750°C and an initial stress level of 18.00 kg mm$^{-2}$. It was observed that those specimens irradiated at the higher temperature showed the greater increase in the creep-rupture strength. This irradiation induced strength increase, presently attributed to the interaction of dislocations with compact vacancy clusters (voids), is in reasonable agreement with the dispersion barrier hardening model. (auth)

**14854** CONTRIBUTION TO THE THEORY OF THE SWELLING OF METALLIC NUCLEAR FUEL. Ristic, M. D. (International Atomic Energy Agency, Vienna); Radenkovic, D. pp 283-94 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB–230(Vol.2); CONF-690620–(Vol.2).

During fuel burn-up in nuclear reactors, the elements are subjected to relatively large and variable temperatures as well as temperature gradients, causing a corresponding variable stress field. At the same time the macroscopic properties of the fuel material are subjected to alterations due to the radiation damage of the microstructure. A model representing the macroscopic behavior of the fuel has to take into account the mutual interaction of nuclear, thermal, and mechanical processes, which involves the dependence of the material characteristics (E, $\nu$, $\alpha$, $\sigma_\xi$ etc.) on the temperature and the burn-up, and at the same time, irreversible density decreasing deformation. Gas bubbles formed from gaseous fission products are weak points in the material, so that tensile stresses, even nominally lower than the material strength, can cause the formation of microcracks, due to the stress concentration effect around the gas bubbles. In this way, elastic tensile stresses relax, though only partially, through the irreversible expansion of microcracks, leading to a corresponding density decrease; elastic compressive stresses, however, can relax only through incompressible plastic deformations. The superposition of density decreasing permanent deformations occurs during prolonged power cycling. Consequently, besides the primary swelling caused by the expansion of gas bubbles, there exists a stress-induced incremental or secondary swelling due to the expansion of the microcracks and the effects of the superposition. The critical burn-up $B_g$, or large swelling threshold, is defined as the starting point for the secondary swelling. The possibility of an effective large swelling control by the appropriate thermal stresses control is suggested. (auth)

**14855** BEHAVIOUR OF HELIUM GAS BUBBLES IN NEUTRON-IRRADIATED BERYLLIUM AND BERYLLIUM ALLOYS. Nagasaki, R. (Japan Atomic Energy Research Inst., Ibaraki); Kawasaki, S.; Ohashi, S.; Karita, Y.; Tsuno, N. pp 331-48 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB–230(Vol.2); CONF-690620–(Vol.2).

A comprehensive transmission electron microscopy was carried out on beryllium and several beryllium alloys irradiated with ~$5 \times 10^{19}$ fast neutrons/cm$^2$ in JRR-2. The study covered the effect of the irradiation on the change in microstructure, the effect of pre-irradiation treatment on the formation of helium gas bubbles upon post-irradiation annealing and the interaction between the bubbles and various precipitates of several intermetallic compounds in the alloys. The binding energy and the retaining force existing between the bubble and the precipitates were calculated from the contact angle between the two phases. By comparing the retaining forces of the precipitates with various driving forces for the migration of helium gas bubbles, the stability of helium gas bubbles attached to the precipitates was evaluated. It was found that formation of the bubbles during post-irradiation annealing of the warm-worked and irradiated beryllium was easier than when irradiated in annealed state. A formation of fine gas bubbles in beryllium, irradiated in the annealed state and post-irradiation annealed at 900°C for 50 hr was noted on grain boundaries and dislocations while, in the specimen irradiated in a worked state, a similar situation was obtained after 3 hr post-irradiation annealing at 750°C. The observed difference in the tendency of bubble formation depends upon the grain-boundary mobility during post-irradiation annealing. In beryllium of relatively low helium concentration, the nucleation and growth of the bubbles occurred preferentially at the grain boundaries, inclusions, precipitates, and dislocation sites. The recrystallization of irradiated beryllium is retarded by the interaction of dislocations with helium atoms. Comparison of the measured retaining force of precipitates with the driving force due to temperature gradient for bubbles showed that in all beryllium alloys used in this work, the gas bubbles attached to the precipitates are stationary under the temperature gradient of 100°C/cm until their radii exceed approximately $4 \times 10^{-4}$ cm. As the retaining force of the precipitates is larger than the driving force due to grain-boundary sweeping, helium gas bubbles attached to the precipitate are not swept away by moving grain boundaries. (auth)

**14856** IRRADIATION EFFECTS IN VANADIUM-BASE ALLOYS. Ehrlich, K.; Boehm, H. (Kernforschungszentrum, Karlsruhe, Ger.). pp 349-55 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB–230(Vol.2); CONF-690620–(Vol.2).

The vanadium-base alloys appears to be suitable cladding materials for fast-breeder reactors due to their favorable neutron physics properties and their high strength at elevated temperatures. The published data on the irradiation behavior of vanadium alloys indicate that they do not show high-temperature embrittlement up to 750°C. There are no results concerning the influence of irradiation on the mechanical properties at temperatures above 750°C. There is great interest in the irradiation behavior of vanadium-base alloys at temperatures about 800 to 900°C, not only because of basic phenomena but also because of practical applications in advanced reactor systems. Since the high-temperature behavior of neutron-irradiated alloys is influenced mainly by the generation of He by (n,$\alpha$)-reactions, it was reasonable to inject $\alpha$-particles directly into the samples by irradiating in a cyclotron. In this way, the influence of He can be simulated within a very short irradiation time. Helium was uniformly injected into small tensile specimens of different vanadium alloys up to concentrations of $1 \times 10^{-4}$ atomic fractions He. Subsequently tensile tests were carried out at 650, 750, 850, and 950°C. In agreement with the results mentioned there was no influence of the irradiation on the ductility at 650 and 750°C, whereas the tests at 850 and 950°C indicate a remarkable decrease in ductility due to irradiation. The yield and ultimate tensile strengths remained unchanged by the presence of helium within the whole temperature range. Metallographic investigations show that the unirradiated samples exhibit transgranular fracture, whereas the irradiated specimens mainly show intergranular fracture in the temperature range of embrittlement. (auth)

**14857** ROLE OF BORON IN THE HIGH-TEMPERATURE IRRADIATION EMBRITTLEMENT OF AUSTENITIC STEEL. Harries, D. R. (Atomic Energy Research Establishment, Harwell, Eng.); Roberts, A. C.; Rogers, G. T.; Hughes, J. D. H.; Dewey, M. A. P. pp 357-81 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

The tensile elongations to fracture at 750°C of 18-10-Nb austenitic steel with boron contents in the range 2 to 97 ppM(wt.) are considerably reduced after irradiation at 650°C to $2 \times 10^{20}$ n $cm^{-2}$ (thermal), the magnitude of the embrittlement increasing slightly with increasing boron content. The tendency for grain-boundary failure is reduced with increasing boron content in the unirradiated thermal control specimens but all the irradiated samples fractured intergranularly. Helium bubbles, 25 to 250 Å in diameter, were resolved by thin-foil transmission microscopy in the unstrained heads of the irradiated tensile specimens. In the 2-ppM boron steel all the bubbles are located at the grain boundaries while the majorities of the bubbles are present within the grains in 43 and 97 ppM boron steels. The fractions of helium present as resolvable bubbles are 0.34, 0.30, and 0.12 for the 2, 43 and 97 ppM boron steels respectively. These discrepancies are explained on the basis of the experimental observations that increasing boron content enhances the formation of $M_{23}(C,B)_6$ precipitates at the grain boundaries. The intense damage, formed adjacent to these precipitates by the energetic products of the $^{10}B(n,\alpha)^7Li$ reaction, produces resolution of the bubbles and bubble nuclei such that the helium is maintained in enforced solution. Thin-foil transmission and stereoscan electron microscopy showed that helium bubbles at some of the grain boundaries enlarge during testing at 750°C. The calculated strains and times to fracture, assuming that failure occurs by growth and coalescence of the bubbles, are broadly in agreement with the experimental data. Recovery of the dislocations and cell formation occurred in the strained gauge lengths of the unirradiated thermal control specimens irrespective of the boron content. However, the degree of dislocation recovery in the irradiated samples decreased with increasing boron content of the steel. It appears that the helium and/or lithium, produced during irradiation by transmutation of the boron-10 atoms, reduce the stacking-fault energy, thereby inhibiting cross slip and climb of the dislocations. (auth)

**14858** OBSERVATIONS ON HELIUM BUBBLES IN AN IRRADIATED 18 Cr-27 Ni AUSTENITIC STAINLESS STEEL. Lindhagen, P. (Aktiebolaget Atomenergi, Studsvik, Sweden). pp 401-9 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

Bubble formation due to helium from the $^{10}B(n,\alpha)^7Li$ reaction has been studied with electron microscope techniques on 18 Cr-27 Ni-Ti-Al. The alloy contained 50 ppM $^{10}B$ to simulate helium generation due to $(n,\alpha)$-reactions with nickel and chromium at very high fast-neutron doses. The alloy was irradiated to a thermal neutron dose of $5 \times 10^{20}$ n/cm² at 675°C. After irradiation no helium bubbles could be detected in foils at magnifications up to about 100,000 times. After post-irradiation tensile and creep tests at 700°C, bubbles with diameters between 100 and 300 Å were formed. The bubbles were mostly located at dislocations and close to precipitates. Bubbles at grain boundaries were slightly larger than the others. The unstressed heads of the creep specimens contained bubbles with a diameter of around 30 to 200 Å. In tensile specimens evidence was obtained that dislocation dragging of bubbles contributes to grain boundary failure. Creep testing at 700°C and low stresses of the same alloy gives a very low creep rate, probably due to bubbles. No direct influence of helium bubbles on crack nucleation and crack growth was observed in that case. (auth)

**14859** A STUDY OF SWELLING AND GROWTH OF URANIUM ALLOYS UNDER IRRADIATION. Lehmann, Jeanne; Blanchard, P.; Paoli, P.; Baron, J. L.; Azam, N. (CEN, Saclay, France). pp 413-38 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

Irradiation experiments were carried out on small samples of uranium alloys under controlled temperature and pressure conditions at burn-ups between 500 and 9000 MWd/t. The alloys studied were of the industrial type, falling into two categories: U-Mo 1.1% alloys and alloys with low Fe, Al, and Si contents. An analysis of the experimental results, based mainly on transmission electron microscopy, optical microscopy, and density measurements, showed that the swelling at 450 to 500°C is already maximal at 500 MWd/t and is due entirely to the presence of fission-gas bubbles. This severe swelling occurs only after some delay in the case of the alloys studied and is characterized by an accelerated rate of swelling. This phenomenon is different from the swelling peak: it appears in the same temperature region, but for very much higher burn-ups. In addition, binary alloys prepared from electrolytic uranium were irradiated for a parallel study of growth and swelling. The alloying elements selected with regard to their atomic radius and their solid solubility in the $\alpha$-phase of the uranium were Si, Ge, Al, C, Fe, Mo, and V. For each composition there are both strongly textured and textureless samples. The results show that certain elements reduce the growth coefficient of pure uranium, while others increase it. The most suitable elements in regard to growth also seem to reduce swelling. Interpretation of the swelling mechanisms for the peak region are presented based on the role of internal stress due to growth and the effect of solid fission products of large atomic diameter. A preponderant influence of either of these factors could explain the differences in swelling observed between different alloys and between alloys and pure uranium. An estimate of the effect of the alloying elements present in alloys which can be used as fuel material is included. (auth)

**14860** INFLUENCE OF NEUTRON RADIATION ON THE PHASE COMPOSITION OF LOW-ALLOYED URANIUM. Lazarevic, Dj. (Boris Kidric Inst. of Nuclear Sciences, Vinca, Yugoslavia). pp 439-46 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

The results of neutron radiation on the resistance of low binary uranium alloys are presented. Two concurrent processes occur—secondary phase precipitation enhanced by a non-equilibrium concentration of vacancies, and re-dissolution due to the action of fission fragments. The kinetics of these processes depends at the constant neutron flux on the type of alloying additives, on the initial state of the alloys and on temperature. By post-irradiation isochronal annealing of alloys irradiated at 450°C, the temperature coefficient of resistivity diminishes. This anomaly is attributed to the growth of microcracks created during irradiation at critical cavitational temperature of 450°C. A method for estimating fuel stability at the early stages of irradiation is proposed. (auth)

**14861** INFLUENCE OF IRRADIATION DAMAGE ON THE PORTEVIN-LE CHATELIER EFFECT IN HYDROGENATED PALLADIUM. Blakemore, J. S. (Australian Atomic Energy Commission Research Establishment, Lucas Heights); Hall, E. O. J. Nucl. Mater.; 34: 114-15(Jan 1970).

The effects of superimposing neutron irradiation damage on yielding in palladium were studied. Stress-strain curves were obtained for palladium wires in four conditions, namely, unirradiated hydrogen-free, unirradiated hydrogenated, irradiated hydrogen-free, and irradiated hydrogenated (the yield stress of these specimens increased in this order). A reasonably well developed Lüders plateau appeared in the unirradiated hydrogenated specimen but was removed by neutron irradiation. (G.M.C.)

**14862** CONTRIBUTION TO THE STUDY OF SECONDARY HARDENING (THERMAL HARDENING) IN $\alpha$-IRON AND IN FERRITIC STEELS. Milasin, Nada (CEN de Saclay, Gif sur Yvette, France). J. Nucl. Mater.; 34: 34-45(Jan. 1970). (In French).

The tensile properties and microhardness of $\alpha$ iron containing 30 to 270 ppM carbon were studied after irradiation to $10^{19}$ n/cm² and after annealing of irradiated samples at the temperatures up to 500°C. A thermal hardening peak was detected for samples annealed around 125°C. These results are compared with the available information on thermal hardening of mild steels and of low alloy steels. On the basis of the influence of certain metallurgical factors and of the irradiation conditions, an attempt is made to identify the type of defect involved in the thermal hardening. (auth)

**14863** PLUTONIUM AND FISSION PRODUCT DISTRIBUTION IN SOME IRRADIATED EXPERIMENTAL MAGNOX FUEL ELEMENT CANS. Hyam, E. D.; Sumerling, R. (United Kingdom Atomic Energy Authority, Seascale, Eng.). J. Nucl. Mater.; 34: 11-20(Jan 1970).

An experimental study was made of the distributions of plutonium and fission products across the wall thickness of some magnesium alloy cans after irradiation at ≈400°C for 20 to 37 months in contact with uranium fuel. Some cans were experimental, of Magnox ZR55 (Mg/0.5 wt % Zr); some were standard, of Magnox

AL80 (Mg/0.8 wt % Al). Plutonium was determined by methods involving controlled abrasion and alpha-counting; fission product activities were measured by photometry of contact autoradiographs. The ZR55 cans contained >100 ppM Pu near the can inner surface and <4 ppM Pu near the outer surface; plutonium had also segregated on the outer surface to the extent of 0.27 $\mu g/cm^3$ in the sample examined. In the AL80 cans, irradiated at a similar temperature for twice the time, plutonium was confined to within 30 to 150 $\mu m$ of the inner surface and over 60% of it was probably on the inner surface itself or in the oxide layer. Fission products had penetrated in substantial quantities to the outer surface of the ZR55 cans, with some segregation at the surface itself. (auth)

**14864** ON THE STRAIN DEPENDENCE OF THE ACTIVATION VOLUME IN IRRADIATED VANADIUM. Pink, Erwin (Univ. of Maryland, College Park). Met. Trans.; 1: 540-1(Feb 1970).

Experimental results are presented as a basis for a method of evaluating activation parameters for irradiated V and other metals. It was found that to obtain the activation volume, an extrapolation to zero strain is essential. Values obtained by strain-rate change at low deformation may not be sufficiently accurate. It was also found that prestrain (sometimes applied at room temperature to prevent low-temperature twinning) reduces the amount of defects and should be avoided. (J.R.D.)

**14865** ANNEALING OF RADIATION DEFECTS AND THE MOBILITY OF ELECTRONS IN INDIUM ANTIMONIDE IRRADIATED BY FAST NEUTRONS. Kurdiani, N. I. Fiz. Tekh. Poluprov.; 3: 1683-6(Nov 1969). (In Russian).

It is shown that the reduction in concentration of electrons in indium antimonide, irradiated at 50°C by fast neutrons, occurs in three stages. Complete reduction of the concentration of electrons occurs after annealing of the crystals at 300°C. The mobility of the electrons also increased in proportion to the increase in annealing temperature. The temperature relation of electron mobility in irradiated and annealed crystals of InSb was studied. In the range from 50 to 120°K, the mobility of the electrons did not depend on temperature. It was postulated that differently charged radiation defects of the dipole type can be responsible for electron scattering in neutron-irradiated and annealed InSb crystals. (tr-auth)

## Ceramics and Cermets

*Refer also to abstracts 14640 and 14641.*

**14866** (BNWL-658) REACTOR FUELS AND MATERIALS DEVELOPMENT PROGRAMS FOR FUELS AND MATERIALS BRANCH OF USAEC DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY. Quarterly Progress Report, July-September 1967. Cadwell, J. J.; de Halas, D. R.; Nightingale, R. E.; Worlton, D. C. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb 1968. Contract AT(45-1)-1830. 208p. Dep. CFSTI.

Research progress is reported on nuclear graphite, graphite-base fuel for gas-cooled reactors, ceramic fuels, preparation of uranium nitride fuels, radiation induced fuel swelling, radiation damage in reactor metals, fast reactor dosimetry and damage analysis, ATR gas loop operation, and metallic fuel development. (J.R.D.)

**14867** (GEMP-1013, pp 15-41) HIGH-TEMPERATURE STUDIES OF URANIUM BASED FUELS. Fryxell, R. E. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Extensive calibration of thermal arrest equipment was used to verify the absence of significant bias in the solidus/liquidus temperatures for urania and indicates an overall accuracy within ±15°C in the composition range $UO_{1.56}$ to $UO_{2.00}$. For oxygen excess compositions, up to $UO_{2.18}$, there is general agreement in the data for W contained and Re contained samples in spite of the extremely different types of interaction between sample and container in the two systems. However, the degree of interaction is large and requires further evaluation. A complete structure analysis of $NaUO_3$ is given. The compound crystallizes in a distorted perovskite-type structure (orthorhombic) and belongs in space group Pbnm. Additions of 0.20 wt % Mo or Cr to $UO_{1.98}$ or $UO_{1.98}$ did not produce the stabilization of single phase $UO_{2-x}$ claimed in a patent disclosure by La Continentale Nucleaire of Luxembourg. Similarly, no stabilization was observed in further evaluation of a series of substoichiometric urania samples melted in and saturated by tungsten. Studies of oxygen migration in $UO_2$ under thermal gradient conditions have shown no measurable composition gradient in 300 hours (1200 to 1700°C) or in 500 hours (900 to 1200°C). Possibly the rate limiting step is the low vapor pressure in this temperature range which prevents mass transfer between stacked pellets in the present capsule design. In 1000 hours in the temperature range 500 to 1300°C, significant oxygen transfer to type 321 or type 347 stainless steel took place, and in the latter case evidence for a small composition gradient in the $UO_2$ was obtained. Preliminary measurements of the compressive creep of $UO_2$ in the temperature range of 1600 to 2000°C demonstrated the reliability of the tungsten loading device and the feasibility of obtaining first stage and second stage deformation rates by use of an electro-optical extensometer. Second stage creep rates of high density specimens (90 and 99% theoretical) were in good agreement with previously reported values. (auth)

**14868** ADVANCED MATERIALS. REFRACTORY FIBRES, FIBROUS METALS, COMPOSITES. Carroll-Porczynski, C. Z. New York; Chemical Publishing Company, Inc. (1969). 382p. $16.50.

Progress in new materials for use where special properties are required is summarized. Chapters are included on high temperature problems, silica fibers, aluminum silicate fibers, potassium titanate fibers, super refractory fibers, asbestos, metallic fibers, and coated fibers. (J.R.D.)

### Corrosion and Erosion

**14869** THERMODYNAMICS AND KINETICS OF OXIDATION OF $Pr_2O_3$ AND $Tb_2O_3$ TO NON-STOICHIOMETRIC OXIDES. Ramdas, S.; Patil, K. C.; Rao, C. N. R. (Indian Inst. of Tech., Kanpur). J. Chem. Soc., A; 31: 64-8(1970).

Isobaric gravimetric studies of $PrO_x$ and $TbO_x$ systems showed the equilibrium existence of several nonstoichiometric phases; the transformation temperatures found by differential thermal analysis agree well with the data from gravimetric studies. Oxidation reactions of $Pr_2O_3$ and $Tb_2O_3$ to nonstoichiometric oxides generally show anomalously high entropy changes (ca. −25 eu/mole of $O_2$) compared with the value of ca. −44 eu/mole of $O_2$ generally found in oxidation of metals. The anomalous entropy changes are shown to arise from configurational factors. Cubic $Pr_2O_3$ with the defect structure is more readily oxidized than the hexagonal $Pr_2O_3$. Kinetic studies show that oxidation of $Pr_2O_3$ is a phase-boundary-controlled reaction. (auth) (UK)

**14870** ENHANCED OXIDATION OF MOLYBDENUM DISILICIDE UNDER TENSILE STRESS: RELATION TO PEST MECHANISMS. Berkowitz-Mattuck, J. B.; Rossetti, M.; Lee, D. W. (Arthur D. Little, Inc., Cambridge, Mass.). Met. Trans.; 1: 479-83(Feb 1970).

The mechanical disintegration of molybdenum disilicide in air or oxygen at temperatures of 300 to 600°C, known in the literature as pest, is ascribed to stress enhanced oxidation at the tips of Griffith flaws, eventually leading to brittle fracture. Stress-free single crystals of molybdenum disilicide, which are not ordinarily subject to peat, were shown to exhibit delayed failure in four-point bend tests under the conditions that lead to pest in polycrystals. The delayed failure times showed the same temperature and oxygen pressure dependence as the times to onset of pest disintegration in polycrystals. Pest in polycrystals occurs even in the absence of an applied stress, due to the high residual stresses which are introduced upon cooling this highly anisotropic material from the melt during fabrication. Nonetheless, the superposition of an applied stress, over and above the residual stress, was shown to decrease the time to pest failure compared with unstressed specimens. The absence of pest above 600°C, and the longer times required for pest disintegration as temperature is increased above about 500°C, is explained by the presence of plastic deformation in the matrix, which tends to reduce stress concentration at the tips of flaws and to counteract the flaw sharpening effect of stress enhanced oxidation. Slip was readily observed at 600°C. The delayed failure results were consistent with the general Charles–Hillig model for the mechanical failure of brittle materials that react chemically with their environment. (auth)

### Preparation and Fabrication

*Refer also to abstracts 13836, 13839, 14658, and 14686.*

**14871** (EUR-4280(Vol.1), pp 305-39) TECHNOLOGIC LIMITATIONS OF THE UTILIZATION OF PRESTRESSED CONCRETE PRESSURE VESSELS. Launay, P. (Compagnie Industrielle de Travaux (Entreprises Schneider) S.A., Paris (France)); Lacroix, R. (Societe Generale d'Entreprises, Paris (France)). (In French).

The technological limitations placed on the utilization of pre-

stressed concrete pressure vessels are illustrated by calculating the effects of varying the characteristics of the material and the permissible stresses, the internal diameter of the cylinder, and the essential external stresses. Extension of the regions of applicability of prestressed concrete can be obtained probably by studies on the improvement of the performance of the base material and better knowledge of its behavior and study of the effect of control devices on the dimensioning. The principle of the bilayered procedure for the construction of pressure vessels is given. An example of the construction and behavior of a bilayered prestressed concrete vessel is presented. The advantage of this procedure with respect to the safety of the pressure vessel are summarized. (J.S.R.)

**14872** (GEMP-722) PREPARATION AND CRYSTALLOGRAPHIC CHARACTERIZATION OF TWO NEW CLASSES OF TERNARY COMPLEX METAL HYDRIDES. Van Houten, Robert; Bartram, S. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs). [1968]. Contract AT(40-1)-2847. 14p. Dep. CFSTI.

Two new classes of ternary metal hydrides were produced and identified. The first of these, $ThZr_2H_x$, ($x > 6$), had a cubic spinel-type hydride. This hydride showed high hydrogen densities, e.g., 6.7 to $7.7 \times 10^{22}$ hydrogen atoms/cm$^3$ and relatively low equilibrium hydrogen pressures at elevated temperatures. The second new class of ternary hydride, represented by $ThTi_2H_8$, (unexpectedly different from the $ThZr_2H_x$ structure) was of the $MgZr_2$ type (hexagonal) structure. This hydride also showed high hydrogen densities, e.g., 8 to $8.8 \times 10^{22}$ hydrogen atoms/cm$^3$ and relatively low equilibrium hydrogen pressures at elevated temperatures. High hydrogen density and low equilibrium hydrogen pressure are a generally sought after combination of characteristics for hydrides to be used in nuclear reactors and in other applications. Accordingly, these two new classes of hydrides and their analogs may be of future use in a variety of applications. (auth)

**14873** (IS-RD-20) REACTOR MATERIALS DEVELOPMENT QUARTERLY [REPORT] FOR THE DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY, U.S.A.E.C, OCTOBER–DECEMBER 1969. Voigt, A. F. (ed.) (Ames Lab., Iowa). 22p. Dep. CFSTI.

Progress is reported on purification of Th by electrotransport, preparation of V metal, purification of V by electrotransport, preparation of U metal by C reduction of $U_3O_8$, extraction of Cs, and preparation of Mo metal. Results of research on phase diagrams of rare earths and refractory metals are included. Ceramics research on diffusion of $Y_2O_3$ and rare earth oxides is reported along with fabrication of $Y_2O_3$ and $Er_2O_3$ shapes and preparation of dense $UO_2$ shapes. (J.R.D.)

**14874** (LA-4298) PYROLYTIC CARBON COATINGS FOR $^{238}PuO_2$ MICROSPHERES: DEVELOPMENT OF COATING AND TESTING PROCEDURES. McCreary, W. J.; Pritchard, W. (Los Alamos Scientific Lab., N. Mex.). Aug 1969. Contract W-7405-eng-36. 13p. Dep. CFSTI.

A laboratory-scale procedure was developed for applying pyrolytic carbon coating to $^{238}PuO_2$ microspheres, a possible energy source for small nuclear reactors for use in space, to contain the radioactive material during the high-temperature phase of reentry into the earth's atmosphere. Very little $^{238}PuO_2$ was available for this study and preliminary work was done with depleted $UO_2$ and $^{239}PuO_2$ microspheres. Pyrolytic carbon coatings were deposited onto the microspheres in fluidized beds at 1200 and 1300°C from methane–helium and acetylene–helium mixtures in a 1-in.-diam graphite coater. The 40-$\mu$-thick pyrolytic carbon deposited at 1200°C from acetylene-helium was laminar and optically active, typical of dense, oriented pyrolytic carbon. These particles survived without apparent damage for 10 min at 1550°C, but 38% of the particles failed after 10 min at 1750°C and all particles were damaged or failed completely after 10 min at 2000°C. The principal mode of failure was shell bursting. The 70-$\mu$-thick coating deposited at 1300°C from methane–helium was optically isotropic and porous. These particles survived without apparent damage for 10 min at 1750°C. After 10 min at 2000°C, most of the particles showed metal migration into the coating, but there were no failures due to shell bursting. Coating and testing procedures are described and photomicrographs and microradiographs of the particles are shown and discussed. (auth)

**14875** (LA-4333) CMF-13 RESEARCH ON CARBON AND GRAPHITE. Report No. 11. Summary of Progress from August 1–October 31, 1969. Smith, Morton C. (Los Alamos Scientific Lab., N. Mex.). 18 Dec 1969. Contract W-7405-eng-36. 31p. Dep. CFSTI.

Research on Santa Maria Coke directed toward grinding, molding, and extrusion of this material is reported. Information is included on internal structure, heat treatment effects on crystal parameters, particle size, densities, and effects of Thermax on Santa Maria fillers. Work is described on graphite extrusion, warm molding of resin-bonded fillers, and porosities of extruded graphites. Other work is reported on development of highly oriented polycrystalline graphite and on the effects of filler particle shape on graphite anisotropy factors. Research effort devoted to development of improved graphite binders is also reported. (J.R.D.)

**14876** IMPROVEMENTS IN OR RELATING TO THE CHEMICAL PRODUCTION OF METAL-CONTAINING MATERIALS AS PARTICLES AND OTHER CONFIGURATIONS. Dress, William; Grimes, John Herbert (to United Kingdom Atomic Energy Authority). British Patent 1,175,834. 23 Dec 1969. Filed 7 Apr 1966.

A process is described for the production of particulate ceramic reactor fuels, such as the oxides or carbides of U, Pu, and Th. An aqueous solution of a salt of the metal is added to a water-soluble organic multihydroxyl polymer. This should not be a cellulosic derivative, which increases in viscosity in alkaline solution, but should form with the aqueous solution a viscous solution of the metal complex and cause this viscous solution to adopt a selected physical configuration. This is followed by treatment with a further solution to precipitate the metal as an insoluble compound. The polymer employed may be a polysaccharide such as dextran, carob gum, gum arabic, alkali-modified starch, or polyvinyl alcohol. The metal solution may be acidic and the precipitating solution alkaline, or vice versa. The metal containing precipitate may be dried and heated to drive off the organic compound. (UK)

**14877** DETERMINATION OF THE ETCH RATE OF SILICON IN BUFFERED HF USING A $^{31}Si$ TRACER METHOD. Hoffmeister, W.; Zuegel, M. (International Business Machines Corp., Boeblingen, Ger.). Int. J. Appl. Radiat. Isotop.; 20: 139-40 (Feb 1969).

During electronic device fabrication Si often comes into contact with HF or $NH_4F$-buffered HF solutions. Macroscopically, Si is considered to be insoluble in HF, but where applications involving electroactive Si layers of ~100 Å are concerned it is important to know whether HF reacts with Si on a microscopic scale. In semiconductor device fabrication etching times of only a few minutes are used, and it is necessary to know the etch rate within this period and adopt a method that will measure etching steps of some Å. Conventional weighing techniques do not meet the requirements, but the use of radioactive $^{31}Si$ allows determination of $5 \times 10^{-8}$ g Si amounts, corresponding to etching steps of 0.1 Å for Si wafers of 3 cm dia, and measurement of the etch rate in 1 min etching time is rendered possible. In the experimental work described neutron-irradiated Si wafers of 0.2 to 0.6 Ω cm n-type, as well as 0.4 and 15 Ω cm p-type were used. Etching was performed in a buffered aqueous HF solution containing 108 ml 48% HF and 350 g $NH_4F$ per 1000 ml, which is a solution frequently employed in semiconductor device fabrication. Details of the experimental procedure are given. The radiotracer measurements were in good agreement with interferometric measurements. The etch rate was independent of time, with a normal value of about 0.4 Å/min. (UK)

**14878** METHOD FOR PRODUCING A CERAMIC FUEL ELEMENT. Hirose, Yasuo (to Hitachi Ltd.). Japanese Patent 1969-22999. 30 Sep 1969. Filed 28 Oct 1964.

A method is proposed for producing a ceramic fuel element that has the following advantages: high density, the elimination of adhered impurities, and the solid cohesion of powder particles. Ceramic fuel powder was put into a metal cladding tube and vibration or shock applied to it to pack the powder tightly. In this process, a step of reducing the pressure within the tube, and another step of heating the powder at below 300°C were incorporated, thus nearly the highest density was obtained. Subsequently, the compacting process was repeated by vibration or shock, while the cladding tube was heated to a point at which the tube was still not damaged. The reduction of pressure in the tube was for removing impurity gases, and the heating was for obtaining the cohesion of powder particles. (NSA of Japan)

**14879** MANUFACTURING CONCEPTS IN APPLICATION OF MOLDED ADVANCED COMPOSITES TO AEROSPACE COMPONENTS. Toth, L. W.; Boller, T. J. (Goodyear Aerospace Corp., Akron, Ohio). pp 361-8 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

Molded advanced fiber composites promise weight savings, increased stiffness, shorter production schedules, and lower potential cost over metal castings and forgings. The matched-die molding

process can form composites into complex shapes. Initial problems with the application of advanced fibers to moldings have been solved. Full-scale demonstrations of working aircraft components now are underway. (auth)

**14880** THERMAL/MECHANICAL STRENGTHENING OF 6061 Al–B COMPOSITES. Dolowy, J. F. Jr.; Taylor, R. J. (Marquardt Co., Van Nuys, Calif.). pp 369-77 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

Recent studies with 6061 matrix aluminum-boron composites have shown noticeable tensile strength improvements when the material is heat-treated to the T6 condition and subsequently cold-rolled. Strength increases of approximately 10% have been achieved for the T6 heat-treatment alone, with significantly larger increases produced by cold-rolling to a thickness reduction of 10%. Mechanisms responsible for this strength improvement such as aluminum matrix strengthening, and relief of fabrication-induced residual stresses are discussed. The mechanisms and the test results are in agreement with the previously developed Mechanical Behavior Model for Al–B Composites. Initial studies do not show any fatigue strength improvement from the heat-treated or heat-treated and rolled material. (auth)

**14881** IMPROVED PROCESS FOR THE PREPARATION OF PELLETS FROM SUBSTANCES WHOSE CONGLOMERATION IS DIFFICULT, AND PRODUCT OBTAINED THEREBY. (to SNAM Progetti SPA, Ltd.). British Patent 1,178,680. 21 Jan 1970. Priority date 18 Jan 1966, Italy.

An improved process is described for chemical production of refractory pellets whose conglomeration is difficult. These pellets can be precipitated by the action of alkalies effected by allowing a mixture of methyl propyl cellulose and an alcoholic salt to fall dropwise in an alkaline solution to form the pellets which are then calcined. Using this process, $ThO_2$ and $UO_2$ pellets can be produced. (J.R.D.)

**14882** APPARATUS FOR THE PRODUCTION OF PYROLYTIC GRAPHITE FROM GASEOUS HYDROCARBONS. Saha, A. R.; Banerjee, P. K.; Das, A. K. (Jadavpur Univ., Calcutta). Indian J. Technol.; 7: 221-3(Jul 1969).

A procedure and an apparatus for the production of pyrolytic graphite from hydrocarbon gases are described. In this apparatus, pyrolytic graphite is deposited on a heated (2000°C) substrate by the pyrolysis of a hydrocarbon gas. A massive deposit of pyrolytic graphite was obtained by the pyrolysis of indane (ordinary cooking gas containing 30% propane and 70% butane). A typical sample thus prepared was about 4 cm in length, 8 mm in width, and 3 mm in thickness. It required about 3 hr to grow a sample of this size at substrate temperature of about 2000°C and 10 mm Hg gas pressure. Unlike industrial graphites, the pyrolytic graphite samples prepared had a metallic gloss. Satisfactory density and anisotropic resistivity were obtained; however, they had the following defects: the thickness of the deposits was not uniform throughout; some bubbles could be observed on the deposits even with the naked eye; and the maximum thickness of the deposit possible with the apparatus used was 3 mm. At a higher pressure (above 12 mm Hg) soots deposited and dendritic growth occurred. This is explained by the fact that at higher pressure the gas phase reaction starts, resulting in the formation of soot outside the substrate which then falls on the substrate. (BBB)

**14883** FOAMED CERAMICS MADE OF MOLTEN QUARTZ AND ZIRCONIUM. Nosova, Z. A.; Denisova, N. N.; Lyubina, T. M. (Scientific Research Inst. of Structural Ceramics, Kuchino, USSR). Steklo Keram.; No. 7, 34-8(1969). (In Russian).

A method of foaming nonplastic materials was devised. This resulted in the very decided strengthening of foam masses before and after drying by adding a small amount of gelatin and formalin (2 to 4 percent). When the latter reacts, adjoining molecular chains are bound across methylene bridges and form a mechanically strong, infusible framework from the jelly converting into an irreversible state. Stable foamed ceramics are obtained with a specific gravity of 0.15 to 0.25 gram/cm$^3$ when different plastic fillers are used—powdered with a specific surface of 4,000 to 6,000 cm$^2$/gram. (JPRS)

**14884** THE PREPARATION OF THIN FOILS FROM SINTERED URANIUM CARBIDE FOR EXAMINATION BY TRANSMISSION ELECTRON MICROSCOPY. Bainbridge, J. E.; Thorne, L. (Atomic Energy Research Establishment, Harwell, Eng.). J. Nucl. Mater.; 34: 202-5(Feb 1970).

A description is given of the bipolar double electrolyte method of electropolishing which was used in the preparation of thin foils of sintered uranium carbide. The foils were prepared for future transmission electron microscopy examination. (G.M.C.)

**14885** PREPARATION OF HIGHLY ORIENTATED PYROGRAPHITE. (to Philips Electronic and Associated Industries, Ltd.). British Patent 1,181,861. 18 Feb 1970. Priority date 5 Jul 1966, Netherlands.

Pyrographite is prepared by deposition from a carbon-containing gas which also contains either sulfur or selenium and may contain oxygen. The deposition is effected on substrates heated at 1700 to 3200°C and at least 100°C cooler than the carbon-carrying gas. The method may be used to remove and replace pyrolytic coatings on fuel particles. (J.R.D.)

**14886** CUBIC VARIETY OF URANIUM OXYSULFIDE. Petitjean, G.; Accary, A. (CEN, Saclay, France). J. Nucl. Mater.; 34: 59-69(Jan 1970). (In French).

Mixtures of uranium disulfide and metallic uranium were submitted to reaction hot pressing at 1200 and 1400°C, the proportion of the two powders being adjusted to yield the monosulphide if a complete reaction took place between them. During this process, the formation of small quantities of a phase which was never described before was observed. This phase appeared as inclusions located in the grains as well as in the grain boundaries. Under the action of a thermal treatment at temperature lower than 1700°C, a coalescence of this phase was observed. If the heat treatment was made at 1700°C, the phase disappeared and the lattice parameter of the monosulfide was changed. The microprobe analysis of this phase showed that it did not contain an element with an atomic number higher than that of carbon, except oxygen, sulfur and uranium. The phase can be approximately described by the formula UOS. X ray diffraction showed that its structure was cubic with a lattice parameter of 6.06 ± 0.03 Å. It is reasonable to assume that this phase is formed either by the insertion of oxygen atoms in the tetrahedral holes of the uranium monosulfide cell, or by substitution by sulfur atoms of certain oxygen atoms in the uranium dioxide. If it is assumed that the U-S and U-O distances in the compound under consideration are the same as in the other known oxygen-sulfur compounds of uranium, it is possible, using the known values, to calculate the lattice parameter of the new phase according to the two different hypotheses described above. The first hypothesis requires that the lattice parameter of the new phase should be equal to that of the monosulfide, i.e., 5.487 Å. The measured parameter differed from this value, and the phase was therefore not the result of the insertion of oxygen atoms in the monosulfide. If sulfur atoms were substituted for oxygen in the dioxide and expansion of the cell should be observed, two limiting values of the lattice parameter, namely, 5.89 and 6.32 Å, can be calculated. The hypothesis based on that structure is thus supported. This hypothesis is further confirmed by the appearance of the phase under study when uranium dioxide and elemental sulfur are heated at temperatures from 800 to 1200°C in a sealed vessel. (G.M.C.)

**14887** PREPARATION OF YTTERBIUM AND EUROPIUM OXIDES IN LIQUID AMMONIA. Fishel, Norman A.; Haschke, John M.; Eick, Harry A. (Michigan State Univ., East Lansing). Inorg. Chem.; 9: 413-14(Feb 1970).

The reactions of oxygen with europium or ytterbium in liquid ammonia were studied. The oxides produced were grayish white. They were extremely finely divided with the entire sample passing readily through a 325-mesh screen. (M.C.G.)

**14888** PRECIPITATION OF THE CARBIDES OF REFRACTORY METALS FROM A GAS MEDIUM. Funke, V. F.; Klement'ev, A. A.; Kosukhin, V. V.; Tyutyunnikov, A. I.; Yamskov, N. S. Porosh. Met., Akad. Nauk Ukr. SSR; No. 12, 39-45(Dec 1969). (In Russian).

The results of investigating the kinetics of growth and phase composition of the precipitates of zirconium, titanium, niobium, and tantalum carbide from a gaseous phase, consisting of metal chloride, methane, hydrogen, and argon are given. It is shown that the dependence of precipitation rate on concentration of methane and hydrogen as well as the temperature of the process reach the maximum. The width of the temperature and concentration region of obtaining monophase precipitates of monocarbides decreased with the fall in thermodynamic strength of chlorides in the series $ZrCl_4 \rightarrow TiCl_4 \rightarrow TaCl_5 \rightarrow NbCl_5$. Some general propositions are formulated on gas-phase metallurgy of refractory metal carbides. (auth)

**14889** PREPARATION AND CHARACTERIZATION OF SUBMICRON HAFNIUM OXIDE. Mazdiyasni, K. S. (Air Force Materials Lab., Wright-Patterson AFB, Ohio); Brown, L. M. J. Amer. Ceram. Soc.; 53: 43-5(21 Jan 1970).

Submicron hafnium oxide powder prepared by hydrolytic decomposition of alkoxides was studied. The particle size range of this

powder was 10 to 50 Å. Emission spectrographic analysis of the powder after it was calcined at 250°C for 0.5 hr indicated a purity of >99.995%. Up to 320°C, the powder showed no crystallinity by x-ray analysis. The amorphous $HfO_2$ was isothermally aged at 5 to 10°C intervals between 200 and 500°C. X-ray diffraction patterns indicated a sharp transition from an amorphous state to the monoclinic phase at 325°C. High-temperature x-ray studies and DTA suggest nucleation and growth of small crystallites at 420°C leading to conversion to monoclinic $HfO_2$ at 480°C. BET surface area measurements and TGA of the powders were also conducted. A powder which transformed at 325°C to the monoclinic phase was isothermally aged below 325°C for 150 hr without change. (auth)

**14890** FINAL STAGE SINTERING OF $ThO_2$. Jorgensen, P. J.; Schmidt, W. G. (General Electric Research and Development Center, Schenectady, N. Y.). J. Amer. Ceram. Soc.; 53: 24-7(21 Jan 1970).

The addition of CaO to $ThO_2$ inhibited discontinuous grain growth and allowed sintering to proceed to theoretical density by maintaining a high diffusion flux of vacancies from the pores to the grain boundaries. The optimum amount of CaO added was 2.0 mole %, which exceeded the solid solubility limit. A model of second-phase inclusions impeding grain boundary motion was used to explain the results. (auth)

## Properties Evaluations

*Refer also to abstracts 13832, 13835, 14163, 14170, 14207, 14210, 14218, 14657, 14698, 14703, 14753, 14875, and 16317.*

**14891** (ANL-Trans-803) ELASTIC CONSTANTS OF URANIUM AND PLUTONIUM CARBIDES, NITRIDES AND OXIDES. Padel, A.; De Novion, Ch. Translated for Argonne National Lab., Ill., from J. Nucl. Mater.; 33: 40-51(1969). 20p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 23: 51115.

**14892** (GEMP-1013, pp 43-51) REFRACTORY METAL FUEL ELEMENT RESEARCH. Collins, J. F.; Newsom, D. L. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Isothermal stability testing of refractory metal clad $UO_2$ cermet fuel element specimens for 10,000 hours or more showed no change in W-Re-Mo or Mo clad fuel specimens at 1200 or 1400°C. Excellent stability was shown by Mo and Mo-TZM clad Mo-$UO_2$ specimens at 1600°C for as long as 17,300 hours in helium. Optimum thermal stability and fuels compatibility was shown by W-Re and W-Re-Mo clad W-$UO_2$ systems at all temperatures to 1800°C. In-pile experiment ORRF-5 was placed on test in the ORR and has operated for 1700 hours at 1640°C maximum temperature. The eight fuel element specimens are designed for complete containment of fission products by accommodation of gases in integral plenums in the end of the fuel elements. With the current burnup level of $8 \times 10^{19}$ fissions/cm$^3$ the effectiveness of the integral plenum and/or high void volume has been demonstrated by the successful irradiation of these specimens to burnup-temperature levels exceeding those of previously tested high density fuel specimens which released fission gases. (auth)

**14893** (GEMP-1013, pp 339-78) FAST BREEDER REACTOR THERMOCOUPLE DEVELOPMENT. Baxter, W. G.; Kuhlman, W. C. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Activities in a program to develop high-temperature thermocouples for fast breeder reactors are summarized. Information is included on fuel element thermocouple materials, thermocouple sheath materials, metal-ceramic seals, electric conductivity of thermocouple wires, calibration of fuel element thermocouples, in-pile testing of thermocouples, and development of sodium coolant thermocouples. (J.R.D.)

**14894** (LA-4211-tr) CALCULATION OF INTERACTION ENERGIES AND CONFIGURATIONAL AND EXCESS ENTROPIES IN SOLUTIONS OF TRANSITION METAL CARBIDES. Andrievskii, R. A.; Zagriazkin, V. N.; Liutikov, R. A. Translated by Helen J. Dahlby (Los Alamos Scientific Lab., N. Mex.), from Conference on Thermodynamics of Nuclear Materials, Vienna, 1967. 6p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 31473. (auth)

**14895** (MLM-1673) BIBLIOGRAPHY OF SELECTED METAL HYDRIDES. Hammond, B. F.; Ratcliffe, H. R. (Mound Lab., Miamisburg, Ohio). 6 Feb 1970. Contract AT(33-1)-Gen-53. 36p. Dep. CFSTI.

This bibliography containing 358 references pertaining to alkali, alkaline earth, transition metal, rare earth, thorium, and uranium hydrides was collected from major American, European, and Russian journals covering a period from 1950 to 1968. Eighteen of the references were published prior to that period. (auth)

**14896** (NYO-3991-5) NONLINEAR ELASTIC AND THERMOELASTIC PROPERTIES OF HIGH-TEMPERATURE MATERIALS. Annual Progress Report. Barsch, G. R. (Pennsylvania State Univ., University Park. Materials Research Lab.). Dec 1969. Contract AT(30-1)-3991. 6p. Dep. CFSTI.

Results of investigations are reported on the nonlinearity of interatomic forces with respect to atomic displacements in high temperature materials such as uranium oxides and alkali halides. Work completed during the period includes compilation of elastic constants of silica, NaI, KI, RbCl, RbBr, and RbI. (J.R.D.)

**14897** (ORNL-4467) DETERMINATION OF RELATIVE THERMAL RUPTURE RESISTANCES OF GRAPHITE. Yahr, G. T. (Oak Ridge National Lab., Tenn.). Jan 1970. Contract W-7405-eng-26. 47p. Dep. CFSTI.

Polycrystalline graphite, which is used as a material for high-temperature application by the nuclear and aerospace industries, has remarkable resistance to thermal-stress-induced fracture. Nevertheless, certain applications tax its thermal rupture resistance, and selection of a particular grade of graphite for such an application must therefore include consideration of this property. Currently the type and grade of graphite are often selected on the basis of figures of merit that have evolved from elastic analyses, since the thermal shock tests that have been developed are too expensive to be used as screening devices. This thermal shock test is rapid enough and sufficiently economical to be used for screening candidate materials for a particular application. The test consisted of heating thin disks of graphite at the center with an inert-gas shielded-arc nonconsumable electrode welder. Several disks of each graphite were heated, each at a different, but constant, power level. The minimum power input to the welder that consistently caused the graphite to fracture was determined. The graphite that required the highest power level to produce a fracture was the one most resistant to thermal shock. Twenty-one grades, or types, of graphite were ranked according to thermal shock resistance by using this test. Mechanical and thermal properties of the specimens were obtained from the literature so that figures of merit ratings could also be determined, and none of the standard figures of merit gave reliable predictions of the relative thermal shock resistances of the graphites. (auth)

**14898** (ORNL-TM-2812) A VISCOELASTIC REPRESENTATION OF THE MECHANICAL BEHAVIOR OF RVD GRAPHITE AT ELEVATED TEMPERATURES. Pugh, C. E. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 33p. Dep. CFSTI.

A set of constitutive equations is developed to describe the time-dependent mechanical behavior of RVD graphite at temperatures ranging from 3500 to 5000°F. The relations are based upon a transversely isotropic linear viscoelastic model with temperature-dependent parameters. This model is shown to be applicable for stress levels up to one-half the nominal ultimate stress values for the material and is expressed quantitatively through the use of experimental results. Predictions of these equations are compared with other experimental measurements including those from short-time stress-strain tests, creep tests, and relaxation tests. (auth)

**14899** (SC-DC-69-1892-B) HELIUM RELEASE DATA FOR $^{238}PuO_2$ MICROSPHERES. Stark, W. A. Jr. (Sandia Labs., Albuquerque, N. Mex.). Nov 1969. 172p. Dep. CFSTI.
Supersedes SC-DC-69-1892.

The results of mass spectrometer analyses of the helium gas released during annealing of production grade, plasma torch fused $^{238}PuO_2$ microspheres are presented for several fuel samples at varying temperatures. Each data set consists of a temperature-time curve, a release rate-time curve, a fractional total release-time curve, and a diffusion coefficient-time curve. The fractional release curve was obtained by integrating the release rate-time curve, and the diffusion coefficient is calculated from the fractional release curve assuming a simple diffusion model with a time-varying diffusion coefficient. (auth)

**14900** (SRIA-106-71) A FUNDAMENTAL STUDY OF FUSED SALTS AND METAL-SALT SYSTEMS. Annual Report of Progress, January 1, 1969-January 1, 1970. Cubicciotti, Daniel (Stanford Research Inst., Menlo Park, Calif.). 7 Jan 1970. Contract AT(04-3)-106. 9p. Dep. CFSTI (U. S. Sales Only).

Effort during the period was devoted mainly to studies of salt vaporization. Results of work on the vapor pressure of molten $NbCl_5$ and the thermodynamics of $NbCl_5$ vaporization below its critical point are presented along with results of investigations

on formation of the gaseous trimer and tetramer of thallous fluoride. Research results are also included on vaporization of thallous nitrate and thallous oxide. Research in progress on thallous sulfate vaporization and liquid-vapor density of $AlCl_3$ is discussed. (J.R.D.)

**14901** (Y-1709) TEMPERATURE STUDY ON A HEATING COIL LOCATED IN AN EVACUATED SAND MEDIUM UNDER QUASI-ISOSTATIC PRESSURE. St. Onge, C. D. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). 10 Feb 1970. Contract W-7405-eng-26. 72p. Dep. CFSTI.

Thesis. Submitted to Univ. of Tennessee, Knoxville.

An experimental and theoretical investigation was made of heat transfer in a system developed for isostatic hot pressing using an evacuated magnesium oxide sand medium. Experimental data on transient temperature distributions were collected and matched with computer results to obtain the best-fit value for the thermal conductivity of the magnesium oxide. An optimum value of 5.3 Btu/hr.-ft.-°F was statistically determined, based upon minimizing deviations between the experimental and theoretical results between 80 and 1,900°F. (auth)

**14902** ISOTROPIC HIGH-TEMPERATURE PLASTICITY OF GRAPHITE. Fischbach, D. B. (Univ. of Washington, Seattle). Phil. Mag.; 21: 1-6(Jan 1970).

A study of the dimensional changes accompanying the high-temperature plastic deformation of a substrate-nucleated pyrolytic carbon suggests that this material deforms like a homogeneous, isotropic solid for elongations greater than about 8%. The initial deformation behavior in tension parallel to the substrate (layer plane) orientation is dominated by a structural transformation involving graphitization and an increase in preferred orientation texture. However, with continued deformation, both the width and the thickness of the gauge section (parallel and normal, respectively, to the layers) decrease at the same rate as a function of elongation, as expected for an isotropic material. Except for a density increase due to graphitization during the first stage, the deformation occurs at constant volume. The implications of this behavior for the fundamental deformation and diffusion mechanisms in graphite are discussed. (auth) (UK)

**14903** ENTHALPY OF FORMATION OF EUROPIUM MONOXIDE. Huber, Elmer J. Jr.; Holley, Charles E. Jr. (Los Alamos Scientific Lab., N. Mex.). J. Chem. Thermodyn.; 1: 301-4(May 1969).

The enthalpy of formation of europium monoxide ($EuO_{1.02}$) was determined by means of oxygen bomb calorimetry and found to be $\Delta H_f^0(298.15°K, EuO_{1.02}) = -(143.3 \pm 0.5)$ kcal/mole. A value of $\Delta H_f^0(298.15°K, EuO) = -(135.0 \pm 1.3)$ kcal/mole was derived. Corrections were applied for the impurities present. It was assumed the $EuH_2$, EuC, and EuN were the contaminants which contributed to the energy of combustion in accordance with their enthalpies of formation and those of their combustion products. It was assumed that the nitride burned to nitrogen. The impurity correction reduced the magnitude of the combustion value by 2.06% to $-(317.8 \pm 1.8)$ cal/g. The uncertainty given for the final value is twice the standard deviation of the mean combined with the uncertainty in the determination of the energy equivalent of the calorimeter and an estimated uncertainty for the impurity correction. If the assumption is made that the $EuO_{1.02}$ is a mixture of EuO and $Eu_2O_3$ (mono) then the material may be considered to be $EuO \cdot 0.021\ Eu_2O_3$. Previous values were reported as $\Delta H_f^0(EuO) = -145.2$ kcal/mole from enthalpies of solution of the metal and of $EuO_{1.02}$ in HCl solutions, and $-(145.2 + 4.1)$ kcal/mole from an effusion method. The reason for the discrepancy is not apparent. (BBB)

**14904** CHARACTERIZATION OF $UO_2$ POWDERS AND ITS APPLICATION IN THE PRODUCTION OF SINTERABLE $UO_2$. Landsperský, Hanus (Inst. of Nuclear Research, Rez, Czech); Podest, Milan; Ristic, Momcilo M. Jad. Energ.; 16: 1-8(Jan 1970).

Methods of characterizing powdered uranium dioxide from the viewpoint of its sinterability were developed for this material and their application was verified on a series of four uranium dioxide powders of different origin and different sinterability. The relations between the results of different methods are discussed in detail. (auth)

**14905** A PRACTICAL METHOD OF FABRICATING EFFICIENT AERO-STRUCTURES, UTILIZING UNIDIRECTIONAL BORON COMPOSITE WITH METAL. Henshaw, J.; Roy, P. J.; Russell, M. D. (Avco Corp., Lowell, Mass.). pp 29-40 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

A fabrication technique is presented for combining the unidirectional strength and stiffness of boron with metal, to produce aircraft structures. The procedure for infiltrating-boron epoxy into hollow elements is explained with projected advantages and typical designs. Test data on strength, stiffness, residual stresses, and shear stresses is presented for typical elements of skin panels, beams, frames, and longerons, with results of weight/cost assessment of a fuselage floor beam. (auth)

**14906** METALLOGRAPHIC STUDY OF FATIGUED UNIAXIAL BORON-EPOXY COMPOSITES. Faller, James G.; Freeman, Richard B. (Boeing Co., Philadelphia). pp 379-90 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

As part of an evaluation of boron-epoxy composites for use in dynamic components of aircraft (for example rotor blades) an introductory study to identify the constituent aspects of their fatigue mechanism was conducted. A post failure analysis, using primarily optical and electron metallography was performed on unidirectional, 0°, fatigued honeycomb sandwich panels. Aspects of failure in fibers, matrix, and at the fiber-matrix interface were studied to varying degrees. Fatigue failure in these composites is explained by the existence of a plane of weakness resulting from cooperative mechanisms such as a rate process of fiber failure due to their statistical strength distribution, a fatiguing of fibers both longitudinally, in the form of split filaments, and transversely, and resin-resin and resin-fiber failure. Split filament topography has been examined in detail and various features interpreted. The morphology of fractured fiber ends and of the resin failure surface have also been investigated. Simple theoretical predictions have been compared with observations made on the number of broken fibers found adjacent to the final fracture. (auth)

**14907** FRACTURE TOUGHNESS OF ALUMINUM-BORON COMPOSITES. Adsit, N. R.; Witzell, W. E. (General Dynamics, San Diego, Calif.). pp 391-8 of Aircraft Structures and Materials Application. Azusa, Calif.; Society of Aerospace Material and Process Engineers (1969).

From National SAMPE Technical Conference, Seattle, Wash. See CONF-690933.

Two different methods of measuring the fracture toughness of aluminum-boron composites were explored. Notched tensile data from specimens with varying thicknesses, orientations, and notch acuities were obtained and compared with data from unnotched specimens. The apparent plane-strain fracture toughness was determined under a variety of conditions. (auth)

**14908** THERMODYNAMIC DATA FOR U-Ce OXIDES. Markin, T. L. (Atomic Energy Research Establishment, Harwell, Eng.); Crouch, E. C. J. Inorg. Nucl. Chem.; 32: 77-82 (Jan 1970).

A gas equilibration method was used to obtain thermodynamic data at 800 to 950°C for substoichiometric uranium-cerium oxides ($U_{1-z}Ce_zO_{2-y}$) where $0.10 < z < 0.75$. Plots of enthalpy and entropy show a striking similarity to enthalpy and entropy plots for (U,Pu) oxides, but a very different behavior to the pure oxide systems $CeO_{2-x}$ and $PuO_{2-x}$. The similarity between entropy and enthalpy plots for the mixed oxides supports the idea that oxygen vacancies cannot locally order in the presence of moderately high concentrations of U(IV) ions. (auth)

**14909** HEAT CAPACITY AT LOW TEMPERATURES, ABSOLUTE ENTROPY, AND ENTHALPY AT STANDARD CONDITIONS OF NIOBIUM NITRIDE. Paukov, I. E.; Strelkov, P. G.; Palitsyn, V. A.; Moroz, E. M. (Inst. of Inorganic Chemistry, Novosibirsk, USSR). Zh. Fiz. Khim.; 43: 2607-9(Oct 1969). (In Russian).

A vacuum adiabatic calorimeter was used to measure the heat capacity of niobium nitride at 13 to 300°K. On the basis of experimental data for heat capacity, the absolute entropy and enthalpies at standard conditions were calculated. Anomalies were not discovered in the temperature-heat capacity curve. (auth)

**14910** DIFFUSION OF INERT GASES IN IONIC CRYSTALS. Norgett, M. J.; Lidiard, A. B. (Atomic Energy Research Establishment, Harwell, Eng.). pp 61-73 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

Calculations of the rate of inert gas diffusion in ionic solids are described. Emphasis is placed on diffusion in the alkali and alkaline earth fluorides which are model systems for reactor fuels.

The classical Born model of an ionic crystal is extended using various plausible forms for the uncertain ion-gas interaction. By relaxing the crystal around the defect, an estimate of the solution energy of the interstitial and its activation energy for migration was made. In addition, the binding energy into intrinsic defects such as vacancies and vacancy pairs was calculated. The results show that both intrinsic defects and vacancy clusters act as traps for gas atoms and suggest that diffusion is largely controlled by the partition of the gas between interstitial and trap sites. These same factors may govern fission gas diffusion in fuel materials. (auth)

**14911** SOLUBILITY OF CARBON IN MOLYBDENUM IN THE SOLID STATE. Zakharov, A. M.; Novikov, I. I.; Parshikov, V. G.; Belykh, Yu. A. (Moscow Inst. of Steel and Alloys). Izv. Vyssh. Ucheb. Zaved., Tsvet. Met.; No. 5, 120-5(1969). (In Russian).

On the basis of microscopic analysis and measurements of microhardness and melting points, the molybdenum side of the phase diagram of the Mo–C system was constructed. The eutectic composition melted at 2270 ± 20°C and contained about 2 wt.% C. The maximum solubility of carbon in molybdenum at the eutectic temperature was about 0.12 wt %. At 2100, 1800, 1500, and 1250°C, the solubility of C in Mo was 0.075, 0.040, 0.0180, and 0.005, respectively. The solubility of carbon in molybdenum at 1250 to 2270°C is described by the equation $\ln C = 4.60 - 12.6 \times 10^3/T$, where C is the at. % carbon and T is the °K. (tr-auth)

**14912** OXYGEN IN URANIUM CARBIDE DURING CARBOTHERMIC REDUCTION PROCESSES. Maruya, Kazuo (Mitsubishi Atomic Power Industries Inc., Saitama, Japan). J. Nucl. Sci. Technol. (Tokyo); 7: 13-18(Jan 1970).

Oxygen retained in UC was considered to be intrinsic to the carbothermic reduction of $UO_2$, so that this reaction was regarded as inherently unsuitable for the preparation of pure UC powder, unless the release of CO gas could be kept within prescribed limits during irradiation. Nevertheless, quantitative considerations on the attainable lower limits of oxygen content in the UC have so far been scarcely reported. The partial pressure of CO gas in the carbothermic reduction and the solubility of oxygen in UC was estimated from thermodynamic considerations. It was established as a result that the reaction had a large temperature dependency, and that the reduction was easily promoted under conditions of high temperature and low pressure, only 0.00456 ppM of oxygen being soluble in UC at 1,550°C under $1 \times 10^{-5}$ mmHg. (auth)

**14913** INTERNAL FRICTION PEAKS NEAR 420°C IN ZIRCONIUM–HAFNIUM–OXYGEN ALLOYS. Gacougnolle, Jean-Louis; Sarrazin, Serge; de Fouquet, Jacques (Ecole Nationale Superieure de Mecanique et d'Aerotechnique, Poitiers, France). Compt. Rend., Ser. C; 270: 158-61(12 Jan 1970). (In French).

Measurements of internal friction in free vibrations effected at 1 cps onto zirconium–hafnium–oxygen alloys showed the formation of an internal friction peak near 420°C, affected by the metal content in oxygen. This peak is identified as a relaxation peak due to the oxygen–hafnium pairs in the α-zirconium. (auth) (France)

**14914** THERMAL VIBRATION AMPLITUDES OF CARBON ATOMS IN THE GRAPHITE LATTICE PARALLEL TO THE BASAL PLANES. Kelly, B. T. (United Kingdom Atomic Energy Authority, Culcheth, Eng.). J. Nucl. Mater.; 34: 189-92(Feb 1970).

The thermal vibration amplitudes of carbon atoms in the graphite lattice parallel to the basal planes were calculated using the lattice dynamics of Komatsu and recent values of the elastic stiffness coefficients. Comparison is made with previous calculations of the out-of-plane vibration amplitudes. (auth)

**14915** COMPATIBILITY OF U(N,C) WITH POTENTIAL CLADDING MATERIALS. Kuroda, Yasuo; Tanaka, Koji; Suzuki, Motokazu; Akimoto, Yumi (Mitsubishi Metal Mining Co., Ltd., Omiya, Japan). J. Nucl. Mater.; 34: 174-81(Feb 1970).

The reactions of potential cladding metals with uranium carbide, nitride, and carbonitrides were examined at elevated temperatures using differential expansion capsules. The metals studied were tantalum, vanadium, V/20 wt % Ti, zirconium, Zircaloy-2, stainless steel (Type 316), Inconel 600, Hastelloy B and C. Among the first four materials, V and V/20 wt % Ti were reactive in comparison with the other two. Following the reaction between V/20 wt % Ti and carbide or carbonitrides, TiC was observed to segregate almost throughout the alloy. In the remaining alloys the reactions were not significant in the experimental conditions, with the exception of Hastelloy B reacting with $U(C_{0.4}, N_{0.6})$. In this couple, heated at 1000°C for 110 hr two reaction bands were formed in the interface region of the alloy. (auth)

**14916** THERMAL DIFFUSIVITY AND THERMAL CONDUCTIVITY OF URANIUM–PLUTONIUM DIOXIDE. Serizawa, M.; Kaneko, H.; Yokouchi, Y.; Koizumi, M. (Plutonium Fuels, Power Reactor and Nuclear Fuel Development Corp., Ibaraki, Japan). J. Nucl. Mater.; 34: 224-6(Feb 1970).

The thermal diffusivity of $(Pu-U)O_2$ was measured at 800 to 1800°C. Thermal conductivities were calculated from the measured diffusivities and estimated heat capacities. (G.M.C.)

**14917** BEHAVIOR OF FISSION PRODUCT RUTHENIUM IN URANIUM CARBIDE. Oi, N. (Atomic Energy of Canada Ltd., Pinawa, Manitoba). J. Nucl. Mater.; 34: 227-9(Feb 1970).

The behavior of metallic fission products, especially ruthenium, in irradiated uranium carbide pins was studied after annealing. The amount of $^{106}Ru-^{106}Rh$ present in the pins increased with annealing time in an Arrhenius relationship. The amount of ruthenium was found to be higher in hypostoichiometric UC than in hyperstoichiometric UC. It is suggested that ruthenium precipitates during irradiation at sufficiently high temperatures. (G.M.C.)

**14918** METHOD OF PREPARING NUCLEAR FUEL ELEMENTS INCORPORATING FISSION PRODUCT RETAINING FUEL PARTICLES. Redding, Geoffrey Brian (to United Kingdom Atomic Energy Authority). U. S. Patent 3,492,379. 27 Jan 1970. Priority date 28 Apr 1966, Great Britain.

Particles of nuclear fuel which have been coated with a fission product retentive layer are formed into an agglomeration by applying a thermosetting synthetic resin to the outer surface of the coating, pouring into a cavity, and heating to set the resin. The resin is applied as a thin layer by tumbling the particles with a resin powder which is softened by contact with a resin solvent. Powdered graphite is mixed with the resin powder to make the mixed powders flowable without difficulty. (Offic. Gaz.)

**14919** SYNTHESIS AND CERTAIN PHYSICAL-CHEMICAL PROPERTIES OF DYSPROSIUM HEXABORIDE. Timofeeva, N. I.; Timofeeva, E. N. Zh. Prikl. Khim.; 42: 2339-42(Oct 1969). (In Russian).

The borothermal method was used to investigate the physicochemical properties of dysprosium hexaboride. $DyB_6$ can be synthesized by the vacuum-thermal reduction of dysprosium oxide by boron at 1550 to 1600°C for 30 to 60 min. The compound was stable in air at temperatures to 600°C, but above 800°C it was highly oxidized. (tr-auth)

**14920** THE STRESS DEPENDENCE FOR HIGH TEMPERATURE CREEP OF POLYCRYSTALLINE URANIUM DIOXIDE. Seltzer, M. S.; Clauer, A. H.; Wilcox, B. A. (Battelle Memorial Inst., Columbus, Ohio). J. Nucl. Mater.; 34: 240-2(Feb 1970).

The stress dependence for high temperature creep of polycrystalline uranium dioxide can be separated into two independent regimes, one occurring for low stresses where the creep rate varies linearly with stress, and a high stress region where the creep rate is dependent on stress to a power n, where n is in the range 4 to 5. The conditions under which a particular stress dependence may be expected were not clearly established. A method is described which can be utilized to predict the stress at which the change in creep mechanism occurs for polycrystalline, stoichiometric $UO_2$. (G.M.C.)

**14921** THERMODYNAMIC PROPERTIES OF THE $V_2O_3-V_4O_7$ SYSTEM AT TEMPERATURES FROM 1400° TO 1700°K. Wakihara, Masataka; Katsura, Takashi (Tokyo Inst. of Tech.). Met. Trans.; 1: 363-6(Feb 1970).

Phase equilibria in the $V_2O_3-V_4O_7$ system were studied at 1400, 1500, 1600, and 1700°K by varying the oxygen partial pressure. Besides the three phases of $V_2O_3$, $V_3O_5$, and $V_4O_7$ which were stable in this system, the vanadium sesquioxide has an extensive range of solid solution at the above mentioned temperatures. The standard free energies of oxidation of both $V_2O_3$ to $V_3O_5$ and $V_3O_5$ to $V_4O_7$ were precisely determined on the basis of equilibrium oxygen partial pressures at each above temperature. The standard enthalpy and the entropy changes of these reactions were also calculated from the free energy data. (auth)

**14922** ROLE OF PARTICLE SIZE AND CARBON CONTENT IN HIGH STRENGTH WC–10 PERCENT Co ALLOYS. Suzuki, Hisashi; Hayashi, Kozi (Tokyo Univ.). Trans. Jap. Inst. Metals; 10: 360-4(Sep 1969).

The effects of mean particle size and carbon content (or binder phase composition) on transverse-rupture strength of WC-10% Co two-phase alloys were investigated, by using specimens having the strength approximately 20 ~ 50% higher than that of the specimens which have been reported by many other researchers. The test on transverse-rupture strength was conducted in accordance with ASTM-B 406-64. Even in such alloys of high strengths, it was confirmed that the strength depended on the carbon content. The

strength of the alloys reached its maximum at a mean particle size of about 2.2 μ. The maximum value was about 350 or 370 kg/mm² in the high or low carbon alloy, respectively. Mechanisms related to the dependence of strength on the carbon content were considered. (auth)

**14923** CRATERING WEAR OF CEMENTED CARBIDES IN RELATION TO CARBON CONTENTS IN TOOLS AND MACHINED STEELS. Suzuki, Hisashi; Yamamoto, Takaharu (Tokyo Univ.). Trans. Jap. Inst. Metals; 10: 351-9(Sep 1969).

The diffusion phenomena between cemented carbides and machined steels, and the cratering wear formed on the carbide tools during cutting of steels were investigated in relation to the carbon contents in both materials. Three sorts of diffusion layers were generally observed, but low carbon WC–Co alloy/low carbon steel combinations resulted in appearance of a fourth layer consisting of $M_6C$-type compound due to decarburization of the alloys. The formation of this compound was markedly checked in WC–TaC–Co and WC–TiC–Co alloys, owing to the effect of tantalum carbide or the β(WC-TiC solid solution) phase acting as a source of carbon. An abnormal increase of wear was observed only in the combination of low carbon WC–Co alloy tools/low carbon steels (or 18-8 stainless steel), due to the formation of that compound just below the cratered surface. In WC–TaC–Co and WC–TiC–Co alloy tools, this abnormal wear was naturally diminished. Resistance to cratering of low carbon WC–TiC–Co alloy tools was superior to that of high carbon tools at a high cutting speed, because of the better mechanical properties at elevated temperatures (as expected from the binder phase composition). It was concluded that the carbon content should be increased in cemented carbides at a low cutting speed, but it should be reduced in WC–TaC–Co or WC–TiC–Co alloys at a high cutting speed. Low carbon WC–TiC–Co alloy tools with particular structure were proved to be very useful for cutting stainless steels steels. (auth)

**14924** TOTAL PRESSURE OF URANIUM-BEARING SPECIES OVER OXYGEN-DEFICIENT URANIA. Tetenbaum, M.; Hunt, P. D. (Argonne National Lab., Ill.). J. Nucl. Mater.; 34: 86-91(Jan 1970).

Measurements of the total pressure of uranium-bearing species over bivariant oxygen-deficient urania compositions, including the difficult region very close to stoichiometry, were made in the temperature range 2080 to 2705°K. The transpiration method was used with flowing $H_2-H_2O$ mixtures in order to fix the oxygen potential of the carrier gases, and therefore, the composition of the condensed phase. The isotherms showed a minimum in the total pressure of uranium-bearing species at a hypostoichiometric composition near the stoichiometric composition. The shapes of the curves were in accord with expectations based on mass spectrometric observations of the vapor species above urania. The logarithm of the total pressure of uranium-bearing species over stoichiometric urania was found to be linear with 1/T over the temperature range investigated. Equations for the temperature dependency of the total pressure of uranium-bearing species above urania in the composition range $UO_{1.85}-UO_{2.00}$ are presented. (auth)

**14925** DIFFUSION IN URANIUM CARBIDE BY THE MASS TRANSFER METHOD. Maiya, P. S.; Routbort, J. L. (Argonne National Lab., Ill.). J. Nucl. Mater.; 34: 111-13(Jan 1970).

Preliminary results of grain-boundary grooving experiments at 1970 to 2185°C on polycrystalline uranium carbide are reported. The feasibility of a systematic study of diffusional processes in uranium carbide using the grain-boundary groove technique is discussed. (G.M.C.)

**14926** SOME PHYSICAL PROPERTIES OF TITANIUM AND ZIRCONIUM DIHYDRIDES. Barantseva, I. G.; Antonova, M. M. (Inst. of Problems in Material Studies, Kiev). Porosh. Met., Akad. Nauk Ukr. SSR; No. 12, 57-9(Dec 1969). (In Russian).

By means of reactive sintering with hydrogen, compact samples of titanium and zirconium dihydrides with the density up to 80% from the theoretically calculated one were obtained. The electric resistivity, Hall constant and coefficient of thermal expansion in the temperature range of 20 to 400°C were measured on the dihydrides samples. On the basis of the obtained physical data suppositions are made on applicability of a one-zone model with electronic type of conductivity to zirconium dihydride and of a two-zone model of coupling with the hole type of conductivity — to titanium dihydride. (auth)

**14927** INFLUENCE OF NONSTOICHIOMETRY AND THE ESTABLISHMENT OF ORDER ON THE MICROHARDNESS OF THE SOLID SOLUTIONS ZIRCONIA–RARE EARTH OXIDES. Lejus, Anne-Marie; Collongues, Robert (Centre d'Etudes de Chimie Metallurgique, Val-de-Marne, France). Compt. Rend., Ser. C; 269: 1198-1200(17 Nov 1969). (In French).

The variation of the microhardness of solid solutions of zirconia–lanthanide oxides was studied, as a function of the nature and the concentration of the lanthanide element and as a function of the phenomena of ordering occurring in the solid solution. (tr-auth)

**14928** THE VAPORIZATION BEHAVIOR OF THE DEFECT CARBIDES. PART I. THE Nb–C SYSTEM. Storms, Edmund; Calkin, Brant; Yencha, Andrew (Los Alamos Scientific Lab., N. Mex.). High Temp. Sci.; 1: 430-55(Dec 1969).

Activity measurements were made in the Nb–C system as a function of composition and temperature using Knudsen effusion in a mass spectrometer. A Langmuir measurement at the congruently vaporizing composition was also made from which absolute pressures were obtained. From these data, the partial heats and entropy of vaporization were obtained for both Nb and C, as well as a heat of vaporization for Nb metal. The thermodynamic cycles showed good internal consistency but suggested that carbon deficient NbC may be partially ordered. A number of conflicts with previously published phase diagrams were found. In particular, $Nb_2C$ apparently decomposed at a much lower temperature into liquid and NbC. Thus, NbC could be made as carbon deficient as ZrC at high temperatures. Various bonding models are discussed and are shown to be inadequate in describing the data. Vaporization data are given for the vapor species $NbC_2$ and NbO. (auth)

**14929** $UO_2$–W CERMETS PRODUCED BY UNIDIRECTIONAL SOLIDIFICATION. Chapman, A. T. (Georgia Inst. of Tech., Atlanta); Clark, G. W.; Hendrix, D. E. J. Amer. Ceram. Soc.; 53: 60-1(21 Jan 1970).

A $UO_2$–W cermet was prepared by direct induction melting of the interior of a mechanically mixed and isostatically pressed $UO_2$-5 to 15 wt % W rod. Preliminary data on the compressive strength, thermal conductivity, electrical resistivity, and crystallographic orientation of the cermet is given. (G.M.C.)

**14930** UNUSUAL POISSON'S RATIOS OF PYROLYTIC GRAPHITE. Bert, Charles W. (Univ. of Oklahoma, Norman). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1814-15(Sep 1969).

Inequalities for the Poisson's ratio for transversely isotropic materials are derived from thermodynamic equilibrium conditions: $-\mu'(2E'/E)^{\frac{1}{2}} < \mu < 1 - 2(\mu')^2\,(E'/E)$ and $-\mu(E/2E') < \mu' < [(1-\mu)(E/2E')]^{\frac{1}{2}}$. From the experimental elastic properties of pyrolytic graphite, the Poisson's ratios ($\mu = -0.21$ and $\mu' = 1.00$) satisfy the inequalities and thus are thermodynamically valid. (D.L.C.)

**14931** DEVELOPMENT AND APPLICATION OF HIGH MATRIX STRENGTH ALUMINUM–BORON. Forest, J. D.; Christian, J. L. (General Dynamics Corp., San Diego, Calif.). Metals Eng. Quart.; 10: No. 1, 1-6(Feb 1970).

Development of improved Al-B composite material is described. Thermal treatments are discussed which double the shear strength of the material. Addition of transverse steel wires increase the cross-tension strength by a factor of 2½. (J.R.D.)

## *Structure and Phase Studies*

*Refer also to abstract 14776.*

**14932** (CEA-R-3841) LOW-ENERGY ELECTRON OBSERVATION OF GRAPHITE AND MOLYBDENITE CRYSTALS. APPLICATION TO THE STUDY OF GRAPHITE OXIDATION. David, Gerard (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec 1969. 57p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Univ. of Strasbourg, France.

A LEED study of cleaved (0001) faces of crystals having a layered structure was used to investigate flakes free of steps on graphite and molybdenite and to show twinnings on natural graphite. By intensity measurements and computation in the case of a kinematical approximation, a 19 eV inner potential for graphite was determined and the direction of the Mo–S bond of the surface layer of molybdenite identified. The oxidation of graphite was studied by observing changes in symmetry of the diffraction patterns and by mass spectrometry of the gases evolved during the oxidation. No surface compounds were detected and the carbon layers appeared to be peeled off one after the other. The oxidation took place at temperatures higher than 520°C under an oxygen pressure of $10^{-5}$ torr. (auth) (France)

**14933** (GAT-T-1585) COMPUTER PROGRAMS TO CALCULATE INTERPLANAR SPACINGS AND X-RAY DIFFRACTION LINE INTENSITIES FOR MATERIALS OF KNOWN STRUCTURE. Thomas, H. H.; Daniel, P. L. (Goodyear Atomic Corp., Piketon, Ohio). 20 Jan 1970. Contract AT(33-2)-1. 35p. Dep. CFSTI.

The two computer programs described are used as aids in indexing powder diffraction patterns. They are written in FORTRAN II for use on the Com-Share time sharing system. One program for the calculation of interplanar spacings (d,A°), requires entry of lattice parameters ($a_0$, $b_0$, and $c_0$) and interaxial angles ($\alpha$, $\beta$, and $\gamma$). Miller indices (h, k, and l) can be entered by the operator or generated by the computer. The second program calculates relative intensities ($I/I_1$) of diffraction lines. This program requires entry of lattice parameters, multiplicities, fractional atomic coordinates, atomic scattering factors, absorption corrections, and temperature corrections. The use of these two programs is illustrated by sample calculations using original diffraction data of $NiF_2$. The complete calculated pattern, d-values and intensities, was compared to the corresponding experimental data. (auth)

**14934** URANIUM-CERIUM-OXYGEN TERNARY PHASE DIAGRAM. Markin, T. L. (Atomic Energy Research Establishment, Harwell, Eng.); Street, R. S.; Crouch, E. C. J. Inorg. Nucl. Chem.; 32: 59-75(Jan 1970).

The U-Ce-O ternary phase diagram was constructed between $UO_2-U_3O_8$ and $CeO_2-CeO_{1.818}$ for all concentrations of Ce and for temperatures between room temperature and 600°C, from results obtained using a high-temperature x-ray powder diffraction camera. Reduction of oxides to a substoichiometric composition where $z > 0.35$ in the general formula $U_{1-z}Ce_zO_{2+x}$ results in the formation of two phases, $MO_{2.00}$ and $MO_{2-x}$, in equilibrium at room temperature. Upon heating the two-phase product a single phase is formed at a temperature dependent on the value of z. The O/M ratio of the $MO_{2-x}$ phases corresponds to only a partial reduction of $Ce^{IV}$ to $Ce^{III}$ and represents an intermediate phase. In this respect the Ce-O and U-Ce-O phase diagrams are similar. Reduction of oxides having $z < 0.35$ results in a single fcc material at all temperatures. Partial oxidation to a superstoichiometric composition when $z < 0.5$ results in either single fcc $MO_{2+x}$ phase or $MO_{2+x}$ in equilibrium with an $M_4O_9$ type phase. Further oxidation causes the disappearance of the $MO_{2+x}$ phase; the $M_4O_9$ type phase is then in equilibrium with a $M_3O_{8-y}$ type phase. Partial oxidation to a superstoichiometric composition when $z > 0.5$ results in a single fcc $MO_{2+x}$ phase. (auth)

**14935** STUDIES OF THE BINARY OXIDES OF ERBIUM AND URANIUM. Kovba, L. M.; Polunina, G. P.; Khromova, M. M. Radiokhimiya; 11: 601-3(1969). (In Russian).

Phase studies were carried out on the system $U_3O_8-Er_2O_3-O_2$. Results show the existence of three two-phase regions: $U_6O_{21+x}$ + $(U,Er)O_{2+x}$; $(U,Er)O_{2+x}$ + $UEr_6O_{12}$; and $UEr_6O_{12}$ + $(U,Er)_2O_{3+y}$. (M.C.G.)

**14936** FUSION DIAGRAM OF THE LiH-$EuH_2$ AND THE LiH-$CeH_2$ SYSTEMS. Mikheeva, V. I.; Kost, M. E. (Inst. of General and Inorganic Chemistry, Moscow). Dokl. Akad. Nauk SSSR; 189: 553-4(1969). (In Russian).

High-purity hydrides of the elements were prepared in a dry box containing less than $10^{-4}$ g/m$^3$ water vapor. The hydride mixture was pressed in a stainless steel cup. Heating was carried out in a quartz vessel equipped for argon flushing. Samples were maintained at a given temperature for 1.5 to 2 hr. The thermal effects which were observed while cooling indicate a eutectic minimum at 7 mol % $EuH_2$ and a maximum near 66% $EuH_2$ with a peritectic point at 40% $EuH_2$. From these data it can be concluded that the double hydrides $LiEuH_3$ and $LiH \cdot 2EuH_2$ (melting at 850°C) can be formed on heating a mixture of lithium and europium hydrides. No chemical interaction of the components could be detected in the LiH-$CeH_2$ system. (TTT)

**14937** STUDY OF $Y_2O_3$-$HfO_2$ SYSTEM IN THE HAFNIUM DIOXIDE-RICH REGION. Isupova, E. N.; Tlushkova, V. B.; Keler, E. K. (Inst. of Chemistry of Silicates, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1948-52(Nov 1969). (In Russian).

Studies were made on the reactions of yttrium oxide and hafnium dioxide in the region rich in $HfO_2$ at 1100 to 2000°C. It was found that the alloys form cubic solid solutions with fluorite type structure. The energy of activation of the reaction during the formation was calculated. The phase diagram of the system was constructed in the region rich in hafnium dioxide. (tr-auth)

**14938** INVESTIGATION OF THE INTERACTION OF ALUMINUM OXIDE WITH EUROPIUM OXIDE. Timofeeva, N. I.; Timofeeva, E. N.; Drozdova, L. N.; Mordovin, O. A. Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1742-4(Oct 1969). (In Russian).

Investigation of the reaction of aluminum oxide with europium oxide in a wide range of concentrations and temperatures showed the presence of two chemical compounds, $EuAlO_3$ and $Eu_2O_3 \cdot 11Al_2O_3$, with melting points of 1940 and 1800°C, respectively. The phase diagram of the system was constructed. Europium monoaluminate has high chemical and thermal stability and high microhardness. (tr-auth)

**14939** PHASE EQUILIBRIA IN THE SYSTEM $Y_2O_3$-$Nb_2O_5$. Bondar, I. A.; Koroleva, L. N.; Toropov, N. A. (Inst. of Chemistry of Silicates, Leningrad). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1730-3(Oct 1969). (In Russian).

Phase equilibria were studied and the diagram of state constructed for the $Y_2O_3-Nb_2O_5$ system. The compound $YNbO_4$ and the berthollide phase based on $Y_3NbO_4$ were found and the limits of the solid solutions determined. (tr-auth)

**14940** BORON-RHENIUM-VANADIUM SYSTEM. Kuz'ma, Yu. B.; Kovalyk, D. A. (Lvov State Univ.). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1687-90(Oct 1969). (In Russian).

Characteristics of compounds in the binary systems V-B and Re-B are given. In the V-Re system, one binary compound, $VRe_3$ ($\sigma$-phase) was formed. It decomposed at approximately 1500°C. Vanadium at 1000°C dissolves approximately 65 at. % rhenium and the solubility of vanadium in rhenium at 2490°C is approximately 50 at. %. X-ray phase analyses of ternary compounds in the system are described. (M.C.G.)

**14941** LATTICE CONTRACTION OF HOT-PRESSED CALCIA-STABILIZED ZIRCONIA. Low, N. M. P.; Chaklader, A. C. D. (Univ. of British Columbia, Vancouver). Mater. Res. Bull.; 5: 137-46(Feb 1970).

The lattice parameter of the cubic fluorite-type solid solution of $ZrO_2$ containing about 15 mole % CaO, produced by hot-pressing, was found to vary with the subsequent heat treatment. The material density was also found to be affected by the subsequent annealing treatment. The decrease of lattice parameter with annealing time appears to be a rate process and the temperature coefficient of this process produced an activation energy of about $1.30 \pm 0.20$ eV, which is similar to the activation energy for oxygen ion diffusion in the CaO-$ZrO_2$ system. (auth)

**14942** LOW-TEMPERATURE PHASE TRANSITION OF VANADIUM SESQUIOXIDE. Nakahira, Mitsuoki; Horiuchi, Shigeo; Ooshima, Hirotoshi (National Inst. for Researches in Inorganic Materials, Tokyo). J. Appl. Phys.; 41: 836-8(Feb 1970).

Specimens of $V_2O_3$ with varying degrees of nonstoichiometry ($x = 0.00$ up to 0.05 for $VO_{1.50+x}$) were prepared and the lattice parameters and magnetic susceptibility measured. The lattice parameters a and c decreased with x, a decreasing more rapidly than c. The susceptibility change and $T_N$ decreased with x; no discontinuous change was observed for highly nonstoichiometric specimens. X-ray diffraction showed that the phase transition from the corundum-type structure to monoclinic below 160°K was observed for $x = 0.006$ but not for $x = 0.034$. (D.L.C.)

**14943** DIAGRAM OF STATE OF THE ALUMINUM-YTTERBIUM SYSTEM. Vengrenovich, R. D.; Psarev, V. I. (Chernovitskii State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Tsvet. Met.; No. 5, 117-19(1969). (In Russian).

An investigation was conducted to obtain information on the phase diagram of Al-Yb. The compound AlYb is apparently stable since prolonged isothermal exposure of alloys at 500 and 600°C did not lead to a change in composition or crystal structure. No appreciable change in the solubility of ytterbium in aluminum-base solutions was observed in nonequilibriumly crystallized alloys. (M.C.G.)

**14944** PHYSICO-CHEMICAL STUDIES OF BINARY SYSTEMS OF SCANDIUM BROMIDE WITH ALKALI METAL BROMIDES. 2. PHASE DIAGRAMS FOR $ScBr_3$-RbBr AND $ScBr_3$-CsBr. Fedorov, N. Ya.; Petrov, E. S. (Inst. of Physics and Chemistry of Mineral Resources, Novosibirsk, USSR). Izv. Sib. Otd. Akad. Nauk SSSR, No. 14, Ser. Khim. Nauk; No. 6, 55-60(Nov 1969). (In Russian).

The phase diagrams of binary systems ScBr-RbBr and $ScBr_3$-CsBr were studied by differential thermal and x-ray analysis. Congruently melting compounds $Rb_2ScBr_5$, $RbSc_2Br_8$, $Cs_2ScBr_5$, and $Cs_2Sc_2Br_8$ were formed in the systems. The melting points of the compounds were 732, 640, 757, and 738°, respectively. The compound $Rb_2ScBr_5$ was polymorphous at 440°. The nonvariant points of the binary system $ScBr_3$-RbBr were eutectic 11.6% $ScBr_3$ and 624°; eutectic 37.8% $ScBr_3$ and 634°; eutectic 49.5% $ScBr_3$ and 585°. The nonvariant points of the binary system ScBr-CsBr were eutectic 8.5% $ScBr_3$ and 596°, eutectic 35.6% $ScBr_3$ and 706°, and eutectic 54.0% $ScBr_3$ and 632°. (auth)

**14945** STRUCTURE OF THE LANTHANUM MOLYBDITE $La_2Mo_2O_{10}$. Hubert, Philippe-Henri; Michel, Pierre; Vincent, Christiane (Faculte des Sciences de Lyon, Rhone, France). Compt. Rend., Ser. C; 269: 1287-9(24 Nov 1969). (In French).

The structure of $La_2Mo_2O_{10}$ was established as face centered cubic with a statistical distribution of the La and Mo ions of the type $CaF_2$ or $Bi_4MoO_9$. (tr-auth)

**14946** SOME OBSERVATIONS ON THE PHASE TRANSFORMATIONS IN ZIRCONIUM HYDRIDES. Barraclough, K. G.; Beevers, C. J. (Univ. of Birmingham, Eng.). J. Nucl. Mater.; 34: 125-34(Feb 1970).

A room temperature x-ray crystallographic and metallographic study was carried out on zirconium hydrides in the composition range $ZrH_{1.27}$ to $ZrH_{1.92}$. Three distinct hydride phases, $\gamma$, $\delta$, and $\epsilon$ were identified. The metastable, fc tetragonal $\gamma$-phase ($c/a > 1$) was observed over the composition range $ZrH_{1.37}$ to $ZrH_{1.57}$ and grew in $\langle 110 \rangle_\delta$ directions on $\{100\}_\delta$ planes. The fcc $\delta$-phase extended from $\sim ZrH_{1.59}$ to $ZrH_{1.66}$ beyond which a martensitic transformation to the fc tetragonal $\epsilon$-phase, ($c/a < 1$) was observed. Considerations of the crystallography add kinetics of the $\delta \rightarrow \epsilon$ transformation are made in relation to previously proposed phase diagrams for hydrogen-rich Zr-H alloys. (auth)

**14947** A NOTE ON THE PLUTONIUM-CARBON-NITROGEN SYSTEM. Potter, P. E. (Atomic Energy Research Establishment, Harwell, Eng.). J. Nucl. Mater.; 34: 193-6(Feb 1970).

The equilibrium nitrogen pressures above the various phase fields of the Pu-C-N system were calculated. The positions of the univariant point X at 1000 to 1900°C are given. (G.M.C.)

**14948** OPTICAL ANISOTROPY IN PYROLYTIC CARBON AND GRAPHITE. Stansfield, O. M. (Gulf General Atomic Inc., San Diego, Calif.). J. Nucl. Mater.; 34: 215-20(Feb 1970).

The influence of surface texture on the optical anisotropy of pyrocarbon and graphite was investigated. The optical anisotropy displayed by plastic replicas of polished surfaces of pyrocarbon and graphite flakes was taken as proof that a substantial portion of the observed optical anisotropy was caused by reflection of plane or elliptically polarized light from furrowed surfaces. (G.M.C.)

**14949** VARIATION OF LATTICE PARAMETER WITH CARBON CONTENT OF NON-STOICHIOMETRIC URANIUM DICARBIDE. Tagawa, Hiroaki (Japan Atomic Energy Research Inst., Ibaraki). J. Nucl. Mater.; 34: 116-18(Jan 1970).

The relationship between the lattice parameter and the composition for nonstoichiometric uranium dicarbide coexisting with carbon as the second phase was determined. (G.M.C.)

**14950** CRYSTAL STRUCTURE OF THE HIGH TEMPERATURE MODIFICATION OF $U_2O_3$. Herak, R. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Acta Crystallogr., Sect. B; 25: 2505-8(1969).

The crystal structure of the high-temperature form of $U_2O_3$ (known as "hexagonal $U_2O_3$") was reinvestigated by a combination of x-ray and neutron powder techniques. It was found that the structure is pseudohexagonal (strictly speaking orthorhombic) space group Amm2. Two of the uranium atoms are bonded to six oxygen atoms forming the corners of a distorted octahedron; the other four uranium atoms are surrounded by seven oxygen atoms, which form an irregular pentagonal bipyramid. All the uranium atoms belong to continuous -O-U-O- chains lying along the a axis. (auth) (Denmark)

**14951** PHASE DIAGRAM OF THE SYSTEMS U-UN-$UO_2$ AND $UO_2$-UN-$N_2$. Martin, J. M. (CEN, Grenoble, France). J. Nucl. Mater.; 34: 81-5(Jan 1970). (In French).

Previous results were complemented and gathered to establish the phase diagram of the system $UO_2$-UN-$N_2$ at one atmosphere. A theoretical perspective view of the diagram is proposed. Experiments performed in argon allowed the determination of the limiting compositions of the dioxide and of the mononitride simultaneously in equilibrium with liquid uranium. The main properties of the U-UN-$UO_2$ phase diagram were specified. (auth)

**14952** FUSIBILITY DIAGRAMS OF LiH-$EuH_2$ AND LiH-$CeH_2$ SYSTEMS. Mikheeva, V. I.; Kost, M. E. (Inst. of General and Inorganic Chemistry, Moscow). Dokl. Akad. Nauk SSSR; 189: 553-4(21 Nov 1969). (In Russian).

High-purity hydrides of the elements were prepared in a dry box containing less than $10^{-4}$ g/m$^3$ water vapor. The hydride mixture was pressed in a stainless steel cup. Heating was carried out in a quartz vessel equipped for argon flushing. Samples were maintained at a given temperature for 1.5 to 2 hr. The thermal effects observed during cooling indicated a eutectic minimum at 7 mol % $EuH_2$ and a maximum near 66% $EuH_2$ with a peritectic point at 40% $EuH_2$. From these data it was concluded that the double hydrides $LiEuH_3$ and $LiH \cdot 2EuH_2$ (melting at 850°C) can be formed on heating a mixture of lithium and europium hydrides. No chemical interaction of the components could be detected in the LiH-$CeH_2$ system. (TTT)

**14953** PARTICULAR LEED FEATURES ON THE $V_2O_5$ (010) SURFACE AND THEIR RELATION TO THE LEED BEAM INDUCED TRANSITION $V_2O_5 \rightarrow V_{12}O_{26}$. Fiermans, L.; Vennik, J. (Univ., Ghent). Surface Sci.; 18: 317-24(Dec 1969).

Particular LEED features on the $V_2O_5$ (010) surface indicate that the LEED beam induced transition $V_2O_5 \rightarrow V_{12}O_{26}$ is initiated by domain formation on the surface of the samples. Two different superstructures were observed, namely $V_{12}O_{26}(010)$-4 × 1 and $V_{12}O_{26}(010)$-1 × 2, on non-stoichiometric samples. (auth)

**14954** DISLOCATION ETCH FOR URANIUM DIOXIDE. Ehman, Michael F.; Faust, J. W. Jr. (Pennsylvania State Univ., University Park). Nucl. Appl. Technol.; 8: 380-3(Apr 1970).

A chemical etchant for $UO_2$ consisting of three parts concentrated HCl and one part concentrated $HNO_3$ is reported. This etchant, when used for ten minutes at 60°C on cleaved {111} surfaces, produces distinctive pits at dislocations intersecting the surface and at low-angle grain boundaries. The fact that the etch pits mark the sites of dislocations was shown by comparing the enlargement of pits with etching time and the etch pits on matching cleavage faces. Comparison of etch rates at various temperatures gave an activation energy of 15.1 kcal/mole. (auth)

**14955** THE LATTICE PARAMETER OF U(C,N) AS A FUNCTION OF COMPOSITION. Leitnaker, J. M.; Potter, R. A.; Spear, K. E.; Laing, W. R. (Oak Ridge National Lab., Tenn.). High Temp. Sci.; 1: 389-400(Dec 1969).

The UC-UN solid solution showed significant variation from Vegard's law. The single-phase region was narrow. The equation $N/(N + C) = 1.00 - 12.6057(a_0 - 4.8892) + 55.8264(a_0 - 4.8892)^2 - 3.38174 \times 10^2(a_0 - 4.8892)^3 - 1.04432 \times 10^4(a_0 - 4.8892)^4$, where $a_0$ is in angstroms, best expresses the lattice parameter-mole fraction relationship. To obtain these results, equilibrium was approached from two directions, and two sides of the single-phase solid solution region were examined. Obtaining true equilibrium between UC and $N_2$ was very difficult even at temperatures as high as 1900°. The lack of complete equilibrium is probably responsible for much of the scatter of lattice parameter versus composition data for U(C,N) in the literature. Careful chemical characterization was carried out on the samples. (auth)

**14956** EQUILIBRIUM INVESTIGATIONS OF CARBON-RICH V(C,N) SOLUTIONS. Spear, Karl E.; Leitnaker, James M. (Oak Ridge National Lab., Tenn.). High Temp. Sci.; 1: 401-11 (Dec 1969).

Relationships of temperature, pressure, lattice constant, and composition are reported for V(C,N) solutions in equilibrium with carbon and nitrogen gas. In accordance with results obtained previously, a dependence of the lattice constant on starting material was observed and attributed to the formation of a thermodynamically active form of carbon as a product of the reaction of VC with nitrogen to form carbonitride solutions. The molar ratio of (N + C) : V was constant at 0.89 ± 0.02 for N : (N + C) ratios less than about 0.2, and then increased to a value of one at the VN boundary. Superstructure lines similar to those caused by the ordering of carbon vacancies in the carbon-rich monocarbide were observed in diffraction patterns of carbonitrides with N : (N + C) ratios less than 0.1. (auth)

**14957** TUNGSTEN BRONZE FIELD AND MELT GROWTH OF CRYSTALS IN THE $Na_2O$-BaO-$Nb_2O_5$ SYSTEM. Giess, E. A.; Scott, B. A.; Olson, B. L.; Burns, G.; O'Kane, D. F. (International Business Machines Corp., Yorktown Heights, N. Y.). J. Amer. Ceram. Soc.; 53: 14-17(21 Jan 1970).

The extent of the liquidus and solidus fields were determined for tungsten bronze-type solid solutions in the $Na_2O$-BaO-$Nb_2O_5$ system by DTA and melt crystal growth experiments. Bronze-type solid solutions existed to $7.1Na_2O$-34.9BaO-$58Nb_2O_5$ in the $Nb_2O_5$-rich region and from $12Na_2O$-38BaO-$50Nb_2O_5$ to $4.6Na_2O$-45.4BaO-50 $Nb_2O_5$ along the $NaNbO_3$-$BaNb_2O_6$ join, which included $NaBa_2Nb_5O_{15} = 10Na_2O$-40BaO-$50Nb_2O_5$. There was little, if any, solid solubility of compositions with a deficiency of $Nb_2O_5$. Curie temperatures declined rapidly and dielectric constant peaks broadened with $Nb_2O_5$ substitution because the Nb : O ratio became greater than the octahedral 1 : 3 ratio. Useful ferroelectrics existed along the $NaNbO_3$-$BaNb_2O_6$ join where the Nb : O ratio was 1 : 3. Large striae-free crystals, with less optical scattering than Czochralski-grown crystals, were grown from unseeded $Na_2O$-rich

melts (e.g., $15Na_2O$-37.5BaO-$47.5Nb_2O_5$) cooled from 1520 to 1300°C at 2°C/hr. Annealing effects on these crystals whose compositions lie on the $NaNbO_3$-$BaNb_2O_6$ join are discussed. (auth)

**14958** SUBSTRUCTURE AND PERFECTION IN $UO_2$ SINGLE CRYSTALS. Chapman, A. T. (Georgia Inst. of Tech., Atlanta); Clark, G. W.; Hendrix, D. E.; Yust, C. S.; Cavin, O. B. J. Amer. Ceram. Soc.; 53: 46-51(21 Jan 1970).

The quality of $UO_2$ single crystals grown by arc-melting, by a modified floating-zone technique (ICZG), and by vapor deposition was studied using etch-pit patterns, electron microscopy, and x-ray topography. These techniques complemented each other and indicated significant variations between the crystals grown by the different techniques. Both types of melt-grown crystals contained extensive substructure and approximately $10^6$ etch pits/cm$^2$; finely dispersed inhomogeneities were found in the vapor-grown crystals. Stoichiometry control during growth permitted a major improvement in the perfection of the ICZG crystals. (auth)

**14959** CATION SELF-DIFFUSION IN LOW DENSITY POLYCRYSTALLINE BERYLLIUM OXIDE. de Bruin, H. J. (Flinders Univ., Bedford Park, Australia). J. Aust. Inst. Metals; 14: 247-54(Nov 1969).

Mass transport is often the rate-determining criterion in solid state processes such as thermal stress-relaxation, sintering, and reactions between solids. These processes commonly take place in powders or polycrystalline compacts of relatively low theoretical density. Their interpretation is based on diffusion data obtained from single crystals or high-density sintered specimens. For ceramic oxides such interpretations are rarely satisfactory and gross discrepancies occur particularly in activation energies for creep and sintering compared with those for self-diffusion of the slowest moving ion. There are as yet no data available in the literature on which to base quantitatively the effects of density on the mass-transport rates in polycrystalline specimens of densities substantially below the theoretical value. Results are interpreted for a number of cation self-diffusion experiments in beryllium oxide specimens of density between 75 and 95% of theoretical. The penetration of $^7Be$ into beryllium oxide was measured as a function of distance for isothermal anneals between 1300 and 1600°C. There is a substantial increase in self-diffusion rates as the density decreases. The data are analyzed in terms of a modified Fisher model for diffusion along grain boundaries. The density-sensitive parameter is the ratio of volume to surface area of the void space between the grains. This ratio varies with density and with the size and shape of the grains. It reaches a maximum value for cubic or spherical grains, which can be calculated from grain size determinations. Assuming a regular and uniform grain size distribution the volume to surface ratio was obtained for all the specimens. It was then possible to calculate coefficients for the self-diffusion of beryllium into these specimens. The activation energy for the overall transport process was found to be 135 ± 20 kcal mol$^{-1}$, a value more than twice that for self-diffusion in high-density material of similar impurity content (63 kcal mol$^{-1}$), and a value remarkably close to the heat of vaporization of beryllium oxide (140–160 kcal mol$^{-1}$). From these data it is concluded that in beryllium oxide powders and low-density polycrystalline specimens an evaporation-condensation mechanism is a definite contributor to the migration of matter in such processes as sintering and grain growth. (auth) (Australia)

## Radiation Effects

*Refer also to abstracts 13874, 14808, 14813, 14814, 14825, 14826, 14828, 14843, and 14846.*

**14960** (AD-696316) EFFECT OF GAMMA RADIATION ON THE MICROHARDNESS OF Ge AND Si SINGLE CRYSTALS. Kaipnazarov, D. K.; Domoryad, I. A. Translated from pp 29-31 of Radiatsionnye Narusheniya v Tverdykh Telakh i Zhidkostyakh, Tashkent, 1967. 7p. (FTD-HT-23-397-69). CFSTI.

The dependence of the microhardness of materials on such factors as the extent of perfection of crystal lattices, degree of purity of the samples, and the condition of the surface is studied. Results on the effects of gamma irradiation on the microhardness of single crystals of Ge and Si are reported. It is shown that the magnitude of hardness obeys a given formula. Curves are plotted of: (1) relative fluctuation of microhardness versus the gamma-ray dosage, (2) isothermic annealing of defects generated by gamma-ray irradiation for various temperatures, and (3) variation of the logarithm of the annealing time for a definite fraction of defects versus the temperature. (auth) (USGRDR)

**14961** (BNWL-1195) METALLOGRAPHIC OBSERVATIONS OF SWELLING IN $U_3Si$. Hann, C. R.; Leggett, R. D.; Mastel, B. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Dec 1969. Contract AT(45-1)-1830. 25p. Dep. CFSTI.

Experimental hollow core $U_3Si$ fuel rods were examined metallographically to determine the type of swelling and the nature of any structural changes in $U_3Si$ irradiated at 370 to 570°C. The initial axial void behaved as designed and filled early in the irradiation to accommodate fuel swelling. Microtearing was identified for the first time as being the primary cause of swelling in $U_3Si$ at these temperatures. Ion bombardment etching proved to be a very effective technique for the examination of irradiated $U_3Si$. (auth)

**14962** (EURAEC-2083(Pt.1)) STUDY OF THE SHAPING AND IRRADIATION OF URANIUM MONOCARBIDE. Quarterly Reports Nos. 25, 26, 27, and 28, July 1, 1967-June 30, 1968. Berthier, J.; Devillard, J.; Morlot, G. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Contract 7589. 60p. (EUR-4006(Pt.1)). Dep. CFSTI.

Work performed under United States-Euratom Joint Research and Development Program.

Details concerning disassembly of capsules containing carbide specimens irradiated in SILOE 4 are presented. Similar information on capsules irradiated in SILOE 5 and EL 3 is included. (J.R.D.)

**14963** (EURAEC-2083(Pt.2)) STUDY OF THE SHAPING AND IRRADIATION OF URANIUM MONOCARBIDE. Quarterly Reports Nos. 25, 26, 27, and 28, July 1, 1967-June 30, 1968. Berthier, J.; Devillard, J.; Morlot, G. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Contract 7589. 52p. (EUR-4006(Pt.2)). Dep. CFSTI.

Work performed under United States-Euratom Joint Research and Development Program.

Radiation testing of carbide specimens in EL 3 reactor is described along with similar tests in SILOE 6. Results of radiation testing of stainless steel-clad uranium carbide in SILOE are included along with information on fabrication of radiation capsules for EL 3. (J.R.D.)

**14964** (EURFNR-688) IRRADIATION OF MIXED URANIUM AND PLUTONIUM CARBIDE AND NITRIDE FUELS IN THE FAST NEUTRON LOOP "MFBS." Mikailoff, Hubert; Leclere, Jacques; Kryger, Bernard; Bloch, Jacqueline; Conte, Madeleine (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Translation of report CEA-N-1186. 103p. Dep. CFSTI.

Work performed under United States-Euratom Fast Reactor Exchange Program.

A description is given, together with results of two irradiation experiments carried out on mixed-carbide and nitride-type fuels. The experiments were done in the fast neutron loop MFBS designed by the Mol Nuclear Research Centre. In one experiment, four small sodium-bonded fuel elements (mixed-carbide, nitride, carbonitride, and alloyed carbide) were tested. The linear power ranged from 1700 to 2400 W/cm and the burnout from 12,500 to 16,000 MWd/t. In another experiment, the behavior of mixed-carbide and nitride fuels clad with helium and sodium bonds and irradiated under particularly severe thermal conditions, was examined (heat flux: 1000 W/cm$^2$; maximum linear power: 3300 W/cm; maximum temperature in nitride fuel: 2500°C). The experiment lasted for ~8 hours and did not involve any thermal cycling. (auth)

**14965** (GEAP-5583) THE ROLE OF FISSION PRODUCTS IN THE SWELLING OF IRRADIATED $UO_2$ AND $(U,Pu)O_2$ FUEL. Anselin, F. (General Electric Co., Sunnyvale, Calif. Advanced Products Operation). Jan 1969. Contract AT(04-3)-189. 37p. Dep. CFSTI.

The contribution of solid fission products to the swelling of irradiated $UO_2$ or mixed $UO_2$–$PuO_2$ fuels was investigated. A model was devised to account for the portion of the increased volume which is due to accumulation of solid fission products as a function of irradiation exposure. The analytical steps involved in synthesis of the model are described. (J.R.D.)

**14966** (GEMP-1013, pp 149-65) TESTING AND EVALUATION OF 710 REACTOR PROGRAM IN-PILE TEST SPECIMENS. Collins, J. F.; Newsom, D. L. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

Post-test evaluations were completed on the series of 18 W-Re-Mo clad W-$UO_2$ fuel element specimens after long-time irradiation in the LITR. All specimens operated up to 1440°C and to burnup of $6.7 \times 10^{19}$ fissions/cm$^3$ were in good condition. Blisters developed on those specimens operated to higher burnup and/or temperature and subsequent fission gas leaks occurred at burnup levels of $7.4 \times 10^{19}$ fissions/cm$^3$ at 1440°C. The use of rhenium for ductilizing the tungsten matrix reduced these burnup temperature

capabilities by about 10%. Better service capabilities have been demonstrated by similar fuel element specimens in previous tests conducted for shorter times (faster burnup). This indicates that the long time irradiation (10,000 hours) reduces the total burnup-temperature capability of the high density W-$UO_2$ fuel element. In unblistered, leak-free specimens, irradiated at 1400°C, 24% of the total gas generated was released by the fuel core; at higher burnup when blistering occurred the released gas increased to 50%. (auth)

**14967** (ORNL-4400, pp 103-17) IRRADIATION BEHAVIOR OF HIGH-TEMPERATURE FUEL MATERIALS. (Oak Ridge National Lab., Tenn.).

Research progress is reported on: in-pile tests of coated fuel particles, in-pile tests of bonded beds of coated fuel particles, fission product release by post-irradiation annealing of coated fuel particles, mechanism of fission gas release from fueled pyrocarbon-coated microspheres, release of iodine from broken coated particles, post-irradiation studies of high-burnup coated particles, experimental test of the FREVAP-8 code for calculating metal fission product release from HTGR fuel elements, and fission gas release and physical properties during irradiation. (M.C.G.)

**14968** (ORNL-4400, pp 147-50) EFFECTS OF NEUTRON IRRADIATION ON REFRACTORY MATERIALS. (Oak Ridge National Lab., Tenn.).

The effects of fast neutrons on refractory metal monocarbides and on alumina were studied. (M.C.G.)

**14969** EXAMINATION OF NEUTRON-IRRADIATED $UO_2$ USING THE SCANNING ELECTRON MICROSCOPE. Reynolds, G. L.; Bannister, G. H. (Central Electricity Generating Board, Berkeley, Eng.). J. Mater. Sci.; 5: 84-5(Jan 1970).

Observations made on neutron irradiated $UO_2$ using a Cambridge Stereoscan SEM illustrate that this method is a satisfactory means of examining the nature of the porosity in the material. It is demonstrated that the amount and nature of the porosity changes with increasing temperature. The small discrete bubbles on the faces are shown to grow and coalesce to form large irregular shaped bubbles. The linkage of bubbles along the grain edges results in formation of tunnels which will contain the gas until intersected by a free surface. (UK)

**14970** IRRADIATION TEST OF THE SUMITOMO TEST ASSEMBLY (STA) IN THE JPDR REACTOR. Ueda, R.; Morishima, A.; Mochizuki, K.; Shimooke, T.; Ezure, H.; Nishiyama, A.; Kido, T.; Fukumitsu, Y.; Kishi, Y. Sumitomo Elec. Rev.; No. 101, 94-102(Nov 1969). (In Japanese).

The fuel assembly was designed and fabricated for the purpose of irradiation testing in the Japan Power Demonstration Reactor (JPDR) of the Japan Atomic Energy Research Institute (JAERI). It was in the form of an 8 × 8 array in a checkerboard arrangement, consisting of 64 Zircaloy-2-clad fuel rods, which included two types of fuel rods, 42 rods of 2.6% enrichment and 22 rods of 59% enrichment. Each $UO_2$ pellet was sheathed in a 0.7 mm thick Zircaloy-2 tube with an outer diameter of 10.9 mm and a length of about 1,800 mm. The fuel rods were supported by upper and lower plates and two spring grid spacers. These two plates were fixed by 8 tie rods, using a double plate system to eliminate the pressure drop at the plate position. The fuel assembly was covered with a Zircaloy-4 channel box. The nuclear, thermal-hydraulic, and mechanical tests of the STA fuel assembly were performed before the irradiation test in the JPDR core. In addition, a pre-irradiation test, flow test, and critical experiment were carried out to check the design calculation. STA was loaded in the JPDR core in April, 1968. Visual inspection of the STA was made in the cooling pond, after an irradiation of about 300 MWd/t. From the results of this inspection, the shapes of the $UO_2$ pellets were observed on the surface of the fuel rods which were irradiated at a relatively high power rating. (auth)

**14971** ROENTGENOGRAPHIC INVESTIGATION OF NEUTRON-IRRADIATED CARBIDES OF TITANIUM AND CHROMIUM. Koval'chenko, M. S.; Ogorodnikov, V. V.; Krainii, A. G.; Ochkas, L. F. (Inst. of Problems of Science of Materials, Kiev). Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1707-11(Oct 1969). (In Russian).

Neutron irradiation at 70 to 80°C causes an increase in lattice parameters of carbides of titanium and chromium. On irradiation of hot-pressed forms of titanium carbide at doses up to $10^{20}$ n/cm$^2$, the dimensions of the blocks and the magnitudes of the microstrain were not changed. The magnitudes of stored energy and concentrations of point defects after irradiation were determined. It was estimated that one neutron creates approximately 50 atomic inclusions. The change in properties on irradiation was observed to be related to the accumulation of point defects. (tr-auth)

**14972** GRAPHITE DAMAGE THROUGH NEUTRON IRRADIATION AT 77°K. A STUDY OF NEUTRON EFFICIENCY IN RELATION TO FLUX ENERGY DISTRIBUTION BY MEASUREMENT OF THE ENERGY RELEASED. Bonjour, E. (CEN, Grenoble, France); Doulat, J.; Mas, P.; Goggin, P. R. pp 83-95 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

Samples of nuclear graphite were irradiated at 77°K under widely differing conditions of neutron energy spectrum and instantaneous flux in the Siloé reactor, CEN, Grenoble, and in the Bepo reactor. Damage was estimated by measuring the energy released between 77 and 570°K. The marked spectrum effect revealed by the measurements is in good agreement with that predicted from the damage calculations of Genthon, which are based on the damage function of Thompson and Wright. The evolution of damage with dose $E(\phi)$ is analyzed on the basis of the displacement zones model proposed by Simmons for neutron-irradiated graphite. The evolution observed follows a simple exponential law of the form $E = E_s(1 - e^{-A\phi})$, and can be explained by the non-cumulative nature of the damage in the recovery volume of the zones, which are initially saturated with defects. This leads to an estimated defect concentration of 1.4% in the zones and an average zone diameter of 17 Å. (auth).

**14973** CORRELATION OF FAST-NEUTRON DAMAGE FOR HTGR CORE MATERIAL. Valette, L. J. (EURATOM, Brussels). pp 97-113 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

The behavior of the fuel elements and graphite under high integrated fast-neutron doses is one of the last pieces of information which has to be known before the fuel cycle of high-temperature reactors can be guaranteed. Research programs have consequently been initiated. Within the framework of the DRAGON and THTR projects tests have been carried out in various research and materials testing reactors, DIDO, BR2, HFR, R2, and DFR, as well as the DRAGON reactor itself. The irradiation temperatures range from 300 to 1250°C and the doses reach maximum values close to $10^{22}$ n/cm$^2$ DIDO Ni equivalent. The interpretation of the results is made difficult by the different definitions of fast flux used in respect of these reactors. Analysis of their neutron spectra has facilitated comparison of the results and their extrapolation to the operating conditions of power reactors. The relative efficiency of the reactors for testing the HTGR materials is analyzed on the basis of the graphite damage function concept. The experimental results obtained from numerous irradiation tests are compared and temperature correction factors for accelerating the tests are proposed. (auth)

**14974** CORRELATION OF GRAPHITE IRRADIATIONS IN THE HIGH-FLUX REACTOR PETTEN AND IN HIGH-TEMPERATURE REACTORS. Reed, D. L. (Atomic Energy Establishment, Winfrith, Eng.); Everett, M. R.; Blackstone, R. pp 115-43 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

The differing neutron energy spectra in the various materials testing reactors has led to the need for accurate calculation of the carbon atom displacement rate and its relation to measured nickel activation dose. Graphite specimens have been irradiated in HFR Petten with the object of calibrating the reactor in terms of equivalent irradiation in DIDO. The results of this calibration experiment are discussed and the calculational method extended to cover the DRAGON Reactor and current designs of HTR power reactors. (auth)

**14975** STUDY OF EJECTION AS A MODE OF FISSION-PRODUCT EMISSION BY URANIUM OXIDE. Hairion, J. P.; Soulhier, R. (CEN, Grenoble, France). pp 297-311 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

A study of ejection, defined as the liberation of fission gases situated near the surface by emerging fission spikes, was made during the irradiation of uranium oxide samples at a temperature below 250°C. With the irradiation devices used, the gases emitted by ejection can be differentiated from those liberated by fission

recoil: these gases, mainly kryptons and xenons and certain of their parent elements, were analyzed quantitatively by gamma spectrometry after irradiation. It has been established that the release of fission gases by ejection is not connected with release by recoil. It depends on the actual surface of the sample and when it occurs the volume of $UO_2$ expelled from its gases does not leave this surface. The kinetics of the phenomenon have been analyzed and the dimensions of the surface layer affected by ejection have been determined experimentally. At a neutron flux of some $4 \times 10^{13}$ n/cm$^2$. s and an irradiation time of sufficient length for equilibrium to be established, it was found that the depth of the surface layer affected by ejection is between 200 and 300 Å; and statistically an emerging fission liberates quantitatively the fission gases present in a volume containing some $10^3$ U atoms. A mathematical model coherent with the experimental results, has been constructed. (auth)

**14976** EFFECTS OF STRUCTURAL CHANGES ON GAS RELEASE MECHANISMS IN $UO_2$. Clough, D. J.; Findlay, J. R.; Nelson, R. S.; Rich, J. B.; Sayers, J. B.; Whapham, A. D. (Atomic Energy Research Establishment, Harwell, Eng.). pp 313-30 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

A variety of experimental techniques has been used to study the distribution of the fission gases with $UO_2$ pellets irradiated over a wide range of irradiation conditions and to correlate the observations with structural changes and the amount of gas released. Thin-film electron microscopy has shown that initially the gas is precipitated in the form of small bubbles ~20 Å dia at a density of about $10^{17}$/cm$^3$. As burn-up proceeds or temperature is increased gas begins to accumulate in grain boundary voids which grow and eventually interlink. Kinetic measurements have been shown that the rate of released short-lived fission gases is directly related to the increase in surface area produced by the grain boundary voids, but is not affected by rating per se. Restraint is also shown to play an important part in the release processes. The importance of resolution in determining the fraction of the gas that reaches the grain boundaries is discussed in the light of the experimental evidence presented. (auth)

**14977** THE EFFECTS OF RADIATION ON HTGR FUEL ELEMENTS. Tytgat, D.; Valette, L. J. (EURATOM, Brussels). pp 465-80 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

A review of the state of development of the HTGR fuel-element concept, with special emphasis on the effects of radiation is presented. The behavior of 40 coated particles of different designs, from different firms or laboratories, under the influence of fast neutrons in the DFR is described. A number of particle designs are proposed, on the basis of these results and the designs proposed by other laboratories. (auth)

**14978** INFLUENCE OF FABRICATION PARAMETERS ON THE INCIDENCE OF SPEARHEAD ATTACK IN COATED PARTICLE FUEL. Huddle, R. A. U. (OECD High Temperature Reactor Project, Winfrith, Eng.); Mayr, K.; Jones, K. W. pp 481-503 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

The initial stages of development of coated particle fuel for high temperature reactors were influenced by the occurrence of spearhead attack, a phenomenon associated with gross shrinkage of pyrocarbon resulting from fission fragment damage. The characteristics of this phenomenon are discussed and methods now available to avoid the problem are described in some detail. The irradiation experiments carried out as part of the Dragon Project fuel irradiation program are summarized with particular reference to the Metallurgical Series I experiments in which a large number of different kernel and coating specifications have been irradiated for 100 and 300 days in the Dragon Reactor Experiment. Details of the post-irradiation metallographic examination are presented. The various mechanisms involved are discussed in relation to the experimental results and particular attention is paid to those factors responsible for the occurrence of spearhead attack, and of its relevance to the performance of coated particle fuel. (auth)

**14979** IRRADIATION DAMAGE STUDY OF PYROLYTICALLY DEPOSITED CARBON COATINGS. Clough, D. J.; Rose, K. S. B.; Sayers, J. B. (Atomic Energy Research Establishment, Harwell, Eng.). pp 505-21 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

Pyrocarbon structures deposited on discs and fuel spheres have been irradiated in the D.F.R. to doses of 4.0 and $10.8 \times 10^{21}$ n/cm$^2$ (DIDO equivalent nickel) at 650 ± 100°C. Results from both geometries were mutually consistent. At the lower dose coated particles with a granular type of structure were intact after irradiation; such coatings have a range of physical properties (i.e., density 2.2 to 1.8 g/cm$^3$. Bacon Anisotropy Factor 1 to 2.5, deposition temperature 1800 to 2200°C, and crystallite size 90 to 200 Å). At the higher dose, however, only granular coatings with a Bacon Anisotropy Factor 1.0 to 1.05 survived, these had densities of 1.8 to 1.9 g/cm$^3$, deposition temperatures 1800 to 1900°C and crystallite sizes of 90 to 120 Å. Inclusion of a silicon carbide coating interlayer did not significantly affect the pyrocarbon coating stability. (auth)

**14980** RADIATION ANNEALING IN GRAPHITE. Gray, B. S. (United Kingdom Atomic Energy Authority, Culcheth, Eng.); Brocklehurst, J. E.; Kelly, B. T.; Soerensen, H.; Dietrich, O. W. pp 523-41 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

The results of an experiment to observe the effect of a change in temperature on the irradiation behavior of reactor quality graphite are presented. Detailed results are given for material irradiated at 150°C to fast neutron doses of up to $3 \times 10^{20}$ n cm$^{-2}$ before further irradiation at 250 and 300°C for doses up to $7 \times 10^{19}$ n cm$^{-2}$. Results are also given for higher initial doses and irradiation temperatures. The observed changes in dimensions, physical properties and stored energy are interpreted on the basis of the existing theories of the defect populations in irradiated graphite and the implications of the results with regard to the damage mechanism are discussed. In particular it is shown that the relaxation dose at 300°C for changes in the concentration of interstitial atoms contained in submicroscopic clusters is about $5 \times 10^{19}$ n cm$^{-2}$ compared with a previous estimate of $10^{19}$ n cm$^{-2}$. (auth)

**14981** IRRADIATION DATA ON GILSOCARBON GRAPHITES FOR HIGH-TEMPERATURE NUCLEAR REACTORS. Blackstone, R. (Reactor Centrum Nederlands, Petten, Netherlands); Graham, L. W.; Everett, M. R.; Delle, W. pp 543-70 of Radiation Damage in Reactor Materials. Vol. II. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.2); CONF-690620-(Vol.2).

Most graphites which have been selected for possible high-temperature power reactor designs are based on Gilsocarbon. This is a naturally occurring pitch in globular form. At graphitization temperature the graphite crystallites arrange in approximately spherical shells and give an isotropic grist particle. Reactor graphites based on this grist can be made isotropic, or near-isotropic, which is very desirable from the viewpoint of dimensional stability under irradiation. Irradiation tests on a number of Gilsocarbon graphites from different manufacturers have been carried out in the HFR-Petten and in the Dragon reactors, reaching a maximum dose of about $5 \times 10^{21}$ n cm$^{-2}$ (Dido equivalent) in the temperature range 600–1200°C. Data are presented on the dimensional changes, the changes in the technologically most important properties and on the creep induced by irradiation. As for the classical reactor graphites the shrinkage rate of the Gilsocarbon graphites increases with temperature in the range 600 to 1200°C. At 900 and 1200°C some of the materials develop anisotropy in their dimensional behavior. A turn-around is observed in both directions at a neutron dose of about $3 \times 10^{21}$ n cm$^{-2}$ at 1200°C, at $4\text{-}5 \times 10^{21}$ n cm$^{-2}$ at 900°C with maximum shrinkage of around 2%. Creep experiments in tension gave radiation creep constants of the order $2\text{-}5 \times 10^{-12}$ (dyne cm$^{-2}$)$^{-1}$ ($10^{20}$ n cm$^{-2}$)$^{-1}$ at 600°C, $4\text{-}10 \times 10^{-12}$ (dyne cm$^{-2}$)$^{-1}$ ($10^{20}$ n cm$^{-2}$)$^{-1}$ at 900°C and $7\text{-}15 \times 10^{-12}$ (dyne cm$^{-2}$)$^{-1}$ ($10^{20}$ n cm$^{-2}$)$^{-1}$ at 1200°C. The radiation effects on the Young's modulus and the electrical resitivity are rather similar to those in other graphite types. At both 900 and 1200°C, after a rapid initial increase in the Young's modulus by about 40 to 50%, a temperature saturation appears, up to about $2\text{-}3 \times 10^{21}$ n cm$^{-2}$, after which the modulus again increases to about twice its preirradiation value. Attempts are made to correlate the observed behavior with other physical properties. The suitability of these Gilsocarbon materials as HTR power reactor graphites is briefly discussed. (auth)

**14982** A RELATION BETWEEN VOLUME AND ELECTRICAL CONDUCTIVITY CHANGES IN IRRADIATED $UO_2$–$SiO_2$ SYSTEM. Cojocaru, L. N. (Inst. for Atomic Physics, Bucharest). Radiat. Eff.; 2: 133-4(Jan 1970).

A correlation between the length l and the conductivity $\sigma$ of neutron-irradiated $UO_2$–$SiO_2$ (20, 40, and 60 mole % $UO_2$) was found: $\Delta \log \sigma / \log \sigma = K\,(\Delta l/l)$. The constant K is ~200 and ~70 for irradiation temperatures of 100 and 250°C, respectively. A possible mechanism for this effect is discussed. (D.L.C.)

**14983** DEFECT-ANNEALING IN FISSION-FRAGMENT-DAMAGED $UO_2$–$SiO_2$ SYSTEM. Cojocaru, L. N. (Inst. of Atomic Physics, Bucharest). J. Nucl. Mater.; 34: 135-41(Feb 1970).

A study was made of the radiation-induced defect annealing in the $UO_2$–$SiO_2$ system for 20 to 60 mole % $UO_2$. It was found that more than 30% of defects remain after athermal recombination and the remaining defects anneal by thermally activated processes at temperatures up to about 750°C, with an activation energy of about 3 eV. The defects formed in $UO_2$ crystallites and in $SiO_2$ containing dissolved $UO_2$ are most probably oxygen vacancies and molecular oxygen respectively. In $SiO_2$ containing dissolved $UO_2$, besides these defects there appeared unbonded U atoms and also atoms resulting from stopping of fission fragments. (auth)

**14984** IRRADIATION-INDUCED CREEP OF PYROLYTIC CARBON IN A GENERAL STATE OF STRESS. Kaae, J. L. (Gulf General Atomic Inc., San Diego, Calif.). J. Nucl. Mater.; 34: 206-8(Feb 1970).

The results of calculation of $\mu_c$, a parameter necessary to describe isotropic radioinduced creep of pyrolytic carbon in a general state of stress, are given. This parameter did not appear to depend on the temperature of irradiation or on the density of the pyrolytic carbon. (G.M.C.)

**14985** THERMAL ANNEALING OF NEUTRON IRRADIATED $SnO_2$. Babeshkin, A. M.; Bekker, A. A.; Efremov, E. N.; Nesmeyanov, A. N. Vestn. Mosk. Univ., Ser. II. Khim.; No. 6, 41-6 (Nov-Dec 1969). (In Russian).

The thermal annealing of radiation damages in $SnO_2$ produced by neutron irradiation ($4 \times 10^{13}$ n/cm$^2$·sec) was studied by nuclear $\gamma$ resonance. (auth)

**14986** SOME RECENT OBSERVATIONS ON CURIUM SESQUIOXIDE. Noe, M.; Fuger, J.; Duyckaerts, G. (Univ. of Liege). Inorg. Nucl. Chem. Lett.; 111-19(Jan 1970).

The rate of the radioinduced transformation of the cubic form of curium sesquioxide into the hexagonal form, as a function of temperature, was studied. The rate of destruction of the cubic lattice, as shown by x-ray diffraction, was much greater at low temperature than at room temperature, while at 300°C, it was essentially negligible. Whereas the monoclinic form of $Cm_2O_3$ was obtained on heating the cubic phase under vacuum, or by reduction of the dioxide, both reactions at temperatures higher than 850°C, it was shown that it can be produced by heating the hexagonal form to 500°C. An expansion in the lattice parameter of the cubic sesquioxide samples was observed during the very first hours following their preparation. This expansion rapidly reaches a saturation value. A contraction of the hexagonal lattice was also noted during the time of its spontaneous formation from the cubic lattice. (auth) (UK)

**14987** CLADDING INTERACTIONS IN MIXED OXIDE IRRADIATED FUELS. Johnson, Carl E.; Crouthamel, Carl E. (Argonne National Lab., Ill.). J. Nucl. Mater.; 34: 101-4(Jan 1970).

Studies of $UO_2$/20 wt % $PuO_2$ fuel clad in Type 304 stainless steel and irradiated to 3.7 atom % burnup have shown substantial attack of the inner cladding wall. Constituents of the stainless steel cladding were transported into the fuel matrix possibly as a result of an intergranular attack. The possibility of an interaction of the cladding with fission products in the fuel with an iodine cycling process is discussed. (G.M.C.)

## Plastics and Other Materials

*Refer also to abstracts 13875, 14117, 14167, 14725, 14879, 14906, 15399, 16180, and 16318.*

**14988** (CEA-CONF-1474) NEW TYPES OF HEAT-INSULATING CONCRETES TO BE USED IN NUCLEAR REACTORS. Dubois, F.; Mauny, P.; Bernard, A.; Elleuch, M. F. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1969. 52p. (In French). (CONF-691112-3). Dep. CFSTI (U. S. Sales Only).

From 2nd Conference on Prestressed Concrete Reactor Vessels and their Thermal Insulation, Brussels, Belgium.

Two types of heat insulating concretes to be used in graphite moderated gas cooled reactors were studied. The first type is made of low-cost molten aluminous cement binder and the second made up of aluminous Super Secar cement binder containing less calcium. The insulation granules are made of expanded clays whose granular voids were filled by an additive product such as vilmolithe. After various experimental temperature testing, the two types of concretes received a total irradiation flux of $10^{19}$ n/cm$^2$ of energy greater than 1 MeV during a month at a minimum temperature of 250°C in $CO_2$. The higher the intensity of flux of irradiation, the more important is the increase of sample weights. Moreover, an important contraction is observed in the irradiated samples and is due to neutron irradiation on expanded clays and vilmolithe granules in the presence of $CO_2$. Young's modulus increases for irradiated samples. The bending and the compressive strengths are not affected by irradiation under $CO_2$ pressure at 230°C. The two types of concretes are found to have a satisfactory behavior. The concrete type 1 containing molten aluminous cement binder can be used up to 350°C. Its ultimate compressive strength always exceeds 100 bars and its thermal conductivity coefficient remains under 0.35 W/m/°C. The concrete type 2 can be used up to 450°C and presents good mechanical and neutron properties. Its thermal insulation properties are less satisfactory. (France)

**14989** (EUR-4280(Vol.1), pp 9-42) EFFECTS OF HEATING AND RADIATION ON STRESS IN CONCRETE. Crispino, E. (Snam Progetti S.p.A., Milan (Italy). (In Italian).

The thermal treatments were initially made on four standard commercial concretes at temperatures up to 200°C. More extensive studies were then carried out on Portland 730 cement. This cement, with an inert filler of baritic nature, is called B.H.T. The thermal tests were made at room temperature and at temperatures up to 500°C to compare the resistance to compression, E modulus, Poisson modulus, resistance to tension, coefficient of thermal expansion, creep, and coefficient of thermal conductivity. In most of these areas the concrete with the inert filler performed better. The results obtained are tabulated in each case. Irradiation tests are being done on the Portland 730 and B.H.T. The irradiation arrangement is described, but the results are not yet available. (J.S.R.)

**14990** (EUR-4280(Vol.1), pp 43-71) EFFECT OF HEATING AND RADIATION ON SOME PROPERTIES OF MORTAR AND CONCRETE SPECIMENS WITH DIFFERENT COMPOSITIONS. Van der Schaaf, C. F. (Bredero N.V., Utrecht (Netherlands)).

Properties of different concrete and mortar specimens were determined before and after irradiation and heating to 400°C. The effects of heating and fast neutron irradiation on the flexural strength and the dynamic modulus of elasticity and the effects of heating on the compressive strength and the heat conductivity of the specimens were investigated. Also several properties important for the selection of the concretes, i.e., the drying shrinkage, the coefficient of expansion, and the unit weight, were studied. (G.M.C.)

**14991** (EUR-4280(Vol.1), pp 79-120) HEAT-RESISTANT CONCRETE WHICH IS STABLE UNDER TEMPERATURE AND PRESSURE OF $CO_2$. Dubois, F. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

Studies made on the development of a heat-resistant concrete stable under temperature and $CO_2$ pressure are reported. A preliminary bibliographic study on possible binders limited the experimental studies to hydraulic binders with a low lime content and to chemical binders with acid base stronger than carbonic acid—especially the trisubstituted phosphates. As a result of preliminary tests, physicochemical studies were made on aluminous binders and on the neutral phosphate of aluminum. The thermal and mechanical tests in a carbon dioxide atmosphere eliminated the aluminum phosphates from consideration. The thermogravimetric and dilatometric test results on the Fondu, Secar 250, and Super Cecar cements were reported and analyzed. The aluminous binders which were hydrated in their stable thermodynamic form had a greater resistance to fissuring with a temperature increase and a greater resistance to carbonization. The composition of eight concretes with the binders Fondu and Super Cecar were determined. Preliminary results obtained on the mass variation, dimension variation, dynamic modulus of elasticity, and the mechanical resistances in compression and tension of these eight concretes after storage of 90 days in air and in water at 20°C were reported. These results suggest that the samples made with Super Secar behave better under the cumulative effects of temperature and $CO_2$ pressure than those made with fused aluminous cement. (J.S.R.)

**14992** (EUR-4280(Vol.1), pp 121-33) DEVELOPMENT OF INSULATION MATERIALS FOR PRESSURE VESSELS. Bremer,

F. (Fried-Krupp Universalbau, Essen (West Germany)). (In German).

Two possibilities for the development of insulation materials, theoretically studied and then subjected to the first experimental tests, are reported. The first method consisted in the development of single grain granulates, or at the most two-grain granulates, with hydraulic, chemical, or ceramic binders using concrete technology methods and their insertion as tamping masses either between casings or better between two thin liner sheets in the proper site and position. Two cross sections of this evacuated concrete are given and preliminary results of its insulating properties are reported. The second method resulted from preliminary studies which showed that dense packing of single-grain granulates without binder are very poor heat conductors even if the packing consists of steel balls. (J.S.R.)

**14993** (EUR-4280(Vol.1), pp 273-81) ANALYSIS AND PHYSICAL PROPERTIES OF SPECIFIC SHIELDING CONCRETES. Steinsdoerfer, F. J. (Fried-Krupp Universalbau, Essen (West Germany)). (In German).

A concrete consisting of 350 kg Portland Cement 375, 143 liters of water, 200 kg barite, 660 kg magnetite, and 1573 kg serpentine was tested for its physical properties between 200 and 350°C after one, five, seven, and ten cycles and five cycles + 28 days storage at normal conditions followed by five more temperature cycles. The results are shown graphically and indicate that the value of the individual construction physical properties was decreased about 10% by the water removal and the material value after the heating was about 25% smaller. The reduction of the material value occurred after the first heating and was not affected by the number of cycles. (J.S.R.)

**14994** (RISO-M-986) CONCRETE–POLYMER MATERIALS. I. PRELIMINARY INVESTIGATIONS OF THE PROPERTIES OF CONCRETE–POLYMER MATERIALS. BFL Intern. Report No. 214. Foerdoes, Z.; Mikkelsen, A. (Betonforskingslaboratoriet, Karlstrup (Denmark)); Singer, K.; Vinther, A. (Danish Atomic Energy Commission, Risoe. Research Establishment). Nov 1969. 24p. (In Danish). Dep. CFSTI (U. S. Sales Only).

A description is given of a preliminary experiment which is part of a joint program established between the Concrete Research Laboratory, Karlstrup (BFL), and the Research Establishment Risö of the Danish Atomic Energy Commission. Gamma-radiation-cured concrete polymer material was made by loading normal cylindrical concrete test specimens with up to 6 wt % of the two polymers: polymethylmethacrylate and poly(styrene/acrylonitrile). Compressive strength and splitting tensile strength were improved by a factor of 5 to 6, while dynamic and static moduli were enhanced by about 70% compared with untreated concrete. (auth) (Denmark)

**14995** AN EXPERIMENTAL STUDY OF THE SPATIAL DISTRIBUTION OF DEFECTS IN ION-BOMBARDED SOLIDS. Boegh, E.; Hoegild, P.; Stensgaard, I. (Univ. of Aarhus, Denmark). pp 77-87 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

The structural damage caused by 60 to 400 keV heavy-ion bombardment of crystalline solids has been studied by using a technique based on the orientation dependence of the Rutherford scattering yield in single crystals. The depth distribution of the structural damage of the crystal can be measured with a depth resolution of ~10% in the range 100 to 10,000 Å. The results to be reported may be summarized as follows: (1) In cases with no annealing during the ion bombardment, the number of displaced atoms is proportional to the energy spent in atomic motion during the slowing-down as obtained from Lindhard's integral equations for the sharing of energy dissipation between electronic and atomic motion. The depth distribution of the displaced atoms is roughly the same as the range distribution of the primary ions. It shows saturation at 100% displaced atoms. (2) The damage rate, the damage distribution, and the annealing behavior show a dependence on the direction of the bombarding ions. Whenever the ions are incident along a crystal axis, the damage rate is decreased by a factor between ~2 and ~20, depending on the ion, its energy, and the target. These directional effects are the results of the occurrence of channeling, which reduces the energy spent in atomic motion by preventing large energy transfers. (auth)

**14996** DISTRIBUTION OF POINT EFFECTS IN OXIDE POWDERS ALONG THE TRACKS OF CHARGED PARTICLES IN THE ENERGY RANGE 10 TO 150 MeV. Nelson, R. L.; Duck, M. J. (Atomic Energy Research Establishment, Harwell, Eng.). pp 97-112 of Radiation Damage in Reactor Materials. Vol. I. Vienna; International Atomic Energy Agency (1969).

From Symposium on Radiation Damage in Solids and Reactor Materials, Vienna, Austria. See STI/PUB-230(Vol.1); CONF-690620-(Vol.1).

Point defects have been produced in alkaline earth oxide powders by irradiation with protons (10 to 50 MeV), $He^{2+}$ ions (40 to 85 MeV), 120 MeV $C^{4+}$ ions and 150-MeV $N^{5+}$ ions. The concentration of F centers, as determined by electron-spin resonance, has been studied as a function of total dose and beam energy. The efficiency of F center production with respect to the total energy loss is constant along the track of a proton or alpha particle and end-of-track effects are not observed. From this it appears that only encounters in which the energy transferred to lattice ions is considerably in excess of $E_d$, the displacement energy, result in stable isolated point defects at irradiation temperatures in the range 20 to 200°C. The efficiencies of F center production for all ion beams studied are similar, with $G_F$ values in the range $2\text{-}5 \times 10^{-4}$, but the range of the ion beam and hence the F center concentration for a given dose may differ by more than two orders of magnitude. The $G_F$ value for reactor irradiation is $\sim 9 \times 10^{-4}$, and this higher value reflects the efficiency of point defect production from elastic collisions involving large energy transfers. The defect production by positive ion beams is compared with theoretical models and contrasted with results from fast neutron and electron irradiation. (auth)

**14997** ACTION OF RADIATION ON ELECTRICAL-ENGINEERING PORCELAIN. Budnikov, P. P.; Kostyukov, N. S.; Antonova, N. P.; Kolotii, I. I.; Medvedovskaya, E. I.; Naidenova, G. A.; Moroz, I. Kh. Izv. Akad. Nauk SSSR, Neorg. Mater.; 5: 1792-6(Oct 1969). (In Russian).

It was concluded that electrical-engineering porcelain is comparatively stable in a beam of thermal neutrons up to $1 \times 10^{20}$ n/cm$^2$. Phase changes in this material at such doses are almost completely lacking, mechanical strength and microhardness decreased slightly, and the coefficient of linear expansion increased. (tr-auth)

# PHYSICS (GENERAL)

## Astrophysics and Cosmology

**14998** ON ZHELEZNYAKOV'S EQUATION OF RADIATIVE TRANSFER IN A MAGNETOACTIVE PLASMA. Walsh, D. (Univ. of Manchester, Jodrell Bank, Eng.). Astrophys. J.; 159: 733-4 (Feb 1970).

Zheleznyakov (1969) proposed a theory of radiative transfer in a nonuniform anisotropic medium that results in the invariant $I/|\cos\vartheta|/n^2$ = constant for a medium with no emission or absorption. Some of Zheleznyakov's equations and conclusions are discussed. (W.D.M.)

### *Cosmic Ray Exposure Ages*

**14999** ISOTOPIC COMPOSITION OF LEAD IN IRON METEORITES. Oversby, Virginia M. (Columbia Univ., Palisades, N. Y.). Geochim. Cosmochim. Acta; 34: 65-75(Jan 1970).

Lead isotopic composition and lead concentration were measured in four troilite samples from Canyon Diablo, two troilites from Toluca, and single troilites from Bogou, Baquedano, Gibeon, Grant, and Staunton. Uranium concentrations were measured in four samples; they ranged from 2.6 to 25 ppb. Observed isotopic compositions were corrected for fractionation by the double-spike technique. The lead compositions ranged from primitive compositions to modern radiogenic compositions. It is concluded that the radiogenic lead found in iron meteorites is due to terrestrial contamination. New values recommended for the primordial lead ratios are $^{206}Pb/^{204}Pb = 9.346$, $^{207}Pb/^{204}Pb = 10.218$, and $^{208}Pb/^{204}Pb = 28.96$. (auth) (UK)

**15000** BISMUTH CONTENTS OF CHONDRITES. Laul, J. C.; Case, D. R.; Schmidt-Bleek, F.; Lipschutz, M. E. (Purdue Univ., Lafayette, Ind.). Geochim. Cosmochim. Acta; 34: 89-103(Jan 1970).

A neutron activation technique has been developed for determination of the bismuth concentrations in C-, H-, L-, and LL-group chondrites. The technique was tested by duplicate analyses of eight standard rocks and a single synthetic sample. The results obtained for standards AGV-1, BCR-1, DTS-1, G-2, GSP-1, and PCC-1 are the first reported. The analyses of 14 carbonaceous and 5 equilibrated ordinary chondrite samples have confirmed that Bi is indeed a "strongly-depleted" element in meteorites. The mean Bi abundances in carbonaceous chondrites are 143, 71, and 37 atoms/$10^9$ Si atoms for groups C1, C2, and C3, respectively, which relative to C1 yield ratios of: C1:C2:C3 = 1.00:0.50:0.26—nearly the same as those predicted by a two-component model. In 12 unequilibrated ordinary chondrites (UOC), the Bi contents generally decrease exponentially with increasing equilibration of the silicate phases although there are apparent exceptions to this trend for chondrites having highly unequilibrated silicates. The Bi concentrations in the UOC correlate well with those of carbon and primordial Ar, Kr, and Xe determined by others in these same meteorites. (auth) (UK)

**15001** ISOTOPIC COMPOSITION OF PRIMORDIAL HELIUM IN CARBONACEOUS CHONDRITES. Anders, E.; Heymann, D.; Mazor, E. (Univ. of Chicago). Geochim. Cosmochim. Acta; 34: 127-31(Jan 1970).

The $^3He/^4He$ ratio of primordial He in carbonaceous chondrites varies with the $^{20}Ne/^{22}Ne$ ratio, according to the relation: $^3He/^4He = (6.87 \pm 0.72) \times 10^{-5} (^{20}Ne/^{22}Ne) - (4.38 \pm 0.76) \times 10^{-4}$. Apparently primordial He, like Ne, consists of at least two distinct components, of $^3He/^4He = (1.25 \pm 0.76) \times 10^{-4}$ and $(4.20 \pm 0.76) \times 10^{-4}$. (auth) (UK)

**15002** TRAPPED HELIUM–NEON ISOTOPIC CORRELATIONS IN GAS-RICH METEORITES AND CARBONACEOUS CHONDRITES. Black, D. C. (Univ. of Minnesota, Minneapolis). Geochim. Cosmochim. Acta; 34: 132-40(Jan 1970).

Stepwise heating experiments were carried out on the dark portions of the gas-rich meteorites Kapoeta, Fayetteville, Pantar, Nogoya, Pultusk, Holman Island, and the C2 carbonaceous chondrite Nogoya light, to determine more precisely the march of trapped helium, neon, and argon. Isotopic variations of up to a factor of 7 exist in trapped-helium and correlate with variations in trapped neon. A plot of trapped $^3He/^4He$ and $^{20}Ne/^{22}Ne$ ratios shows that gas-rich meteorites define a zone, called the GRZ. The carbonaceous chondrite Nogoya and several analyses of the carbonaceous chondrite Mokoia define a "carbonaceous chondrite corridor" which is distinct from the GRZ. Trapped helium and neon in meteorites are found to result from a multicomponent mixture. The primary trapped components may be related by a nuclear process; mass fractionation is shown to have played a minor role in altering the trapped helium–neon compositions. (auth) (UK)

**15003** $^{81}Kr$ RADIATION AGES OF STONE METEORITES. Rowe, M. W. (Texas A and M Univ., College Station). Nature (London); 225: 368(24 Jan 1970).

Krypton-81, the first cosmic-ray produced radionuclide heavier than the Ni–Fe group, was recently discovered in stone meteorites, and the radiation ages of the meteorites were evaluated by measurements of only the Kr isotopic composition. It is noted that the radiation age estimated from $^{81}Kr/^{78}Kr$ appears systematically greater than the published $^3He$ radiation ages. It is suggested that the relative production rate $P(^{81}Kr)/P(^{78}Kr)$ may have been overestimated. The $^{81}Kr/^{78}Kr$ ages of seven stone meteorites are recalculated assuming that $P(^{81}Kr) = \frac{1}{2}[P(^{80}Kr) + P(^{82}Kr)]$, as assumed earlier, and that $P(^{81}Kr) = P(^{80}Kr)$. Good agreement was obtained with $^3He$ ages on the latter assumption. (UK)

### *Stars*

*Refer also to abstracts 14792, 15123, 15528, and 15673.*

**15004** PHOTOMETRY OF BL LACERTAE WITH A TIME RESOLUTION OF 15 SECONDS. Racine, Rene (Univ. of Toronto). Astrophys. J.; 159: L99-103(Feb 1970).

New photometric observations of the strange object BL Lac = VRO 42.22.01 are reported with the following results: (1) The brightness of BL Lac fluctuates by 0.1 mag over a few hours. (2) Flickers of amplitudes $\Delta V \simeq 0.03$ mag and durations as short as $\Delta t = 2$ min are detected. (3) The (B–V) and (U–B) colors of BL Lac become redder with decreasing brightness. Similarities between BL Lac, N-type galaxies, and Seyfert nuclei are mentioned. (auth)

**15005** OBSERVATIONS OF HIGHLY ECCENTRIC ORBITS IN THE PLEIADES CLUSTER. Jones, Burton F. (Univ. of Chicago, Yerkes Observatory, Williams Bay, Wis.). Astrophys. J.; 159: L129-31(Feb 1970).

New relative proper motions were determined for fifty-two Pleiades stars on plates taken with the 40-inch refracting telescope at Yerkes Observatory, which have a time baseline of up to 66 years. These motions show that stars at distances greater than 20 minutes of arc from the center of the cluster have internal motions that are almost completely in a radial direction, an observation which indicates that these stars are in highly eccentric orbits. (auth)

**15006** WEAK MAGNETIC FIELDS OF SOME BRIGHT STARS. Severny, A. (Crimean Astrophysical Observatory, USSR). Astrophys. J.; 159: L73-6(Feb 1970).

The technique of the solar magnetograph applied at the coudé spectrograph of the 2.6-m reflecting telescope of the Crimean Astrophysical Observatory for the measurement of stellar magnetic fields has recently revealed weak longitudinal magnetic fields (30 to 300 gauss) of some bright stars. (auth)

**15007** $\nu$ INDI: A WEAK-LINED HALO STAR WITH EXCESS DEFICIENCY OF NITROGEN. Harmer, J. L.; Pagel, B. E. J. (Royal Greenwich Observatory, Herstmonceux, Eng.). Nature (London); 225: 349-51(24 Jan 1970).

It is stated that the weakness of uv CN bands in the spectrum of $\nu$ Indi implies that, whilst C and metals are deficient (compared with the Sun) by a factor of about 15, N is still more deficient by a factor of between four and eight. (auth) (UK)

**15008** THE SPECTRUM OF $\alpha^2$ CVn. II. Cohen, Judith G. (Carnegie Institution of Washington D. C. California Inst. of Tech., Pasadena). Astrophys. J.; 159: 473-84(Feb 1970).

The behavior of the continuum of $\alpha^2$ CVn has been studied. The Balmer discontinuity does not vary but the slope of the Paschen continuum changes over the cycle. The line-blanketing coefficients have been measured at several phases and do not change sufficiently to produce the observed variations of the continuum. The effective temperature (12,000°K) and surface gravity (log g = 4.0) are determined from the scans and hydrogen-line profiles, and the behavior of equivalent width as a function of phase is discussed. A crude abundance analysis is performed, which shows that the iron peak is enhanced above the solar value and that the rare earths are even more overabundant than was previously thought. The results of the abundance analysis are discussed in terms of a first-order oblique-rotator model, and the implications for the theory of Ap stars are described. (auth)

**15009** THE UNUSUAL COMPOSITION OF +39°4926. Kodaira, Keiichi; Greenstein, Jesse L.; Oke, J. B. (Carnegie Institution of

Washington, D. C. California Inst. of Tech., Pasadena). Astrophys. J.; 159: 485-512(Feb 1970).

The extremely metal-poor star, +39°4926 has $T_e$ + 7500°K, log g = 1, and a very large Balmer jump (1.7 mag). Model atmospheres explain the hydrogen spectrum, and over plausible ranges of $T_e$ the abundances are insensitive to errors in $T_e$. Weak lines of He I are present, but the He/H ratio is temperature-dependent. Strong lines of C I and O I are observed and yield abundance ratios C/H and O/H near that in the Sun and insensitive to $T_e$. The metal abundances average 1% of their solar values, differ from element to element, and show an excessively large odd-even alternation. The velocity seems variable in a long period. The absolute magnitude is near −3, the mass less than the Sun. The unusual location of the stars in the H−R diagrams for either Population I or Population II may be connected with rapid evolution with mass exchange. Nucleosynthesis of C and O may have occurred rapidly in exploding stars early in the history of the Galaxy. C, O, and products of helium burning were rapidly synthesized. Alternatively, the star may have synthesized C and O rapidly in its interior, at a time when it was more massive. The odd-even alternation suggests that α-particle capture has been particularly important; neutron-capture products are rare. (auth)

**15010** THE ATMOSPHERE OF THE HYDROGEN-DEFICIENT STAR SIGMA ORIONIS E. Klinglesmith, D. A.; Hunger, K.; Bless, R. C.; Millis, R. L. (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. J.; 159: 513-23(Feb 1970).

A fine analysis of the hydrogen-deficient star σ Ori E is performed using a grid of constant-flux model atmospheres. Sources of opacity considered are H I, $H^-$, He I, He II, $He^-$, electron scattering, and Lyman and Balmer lines. The parameters of the models are: $T_{eff}$ = 20,000°K, 25,000°K; log g = 2.5, (0.5), 4.5; X (mass fraction of hydrogen) = 0.6667, 0.143, 0.0164. The following quantities are computed: the profiles and equivalent widths of Hγ, Hδ, and five He I lines; the Balmer and helium discontinuities; the slope of the Paschen continuum; UBV colors; and bolometric corrections. The observations include ten high-dispersion spectrograms and photoelectric scans of the continuum. The model that fits the observations best has $T_{eff}$ = 23,500°K, log g = 4.05, X = 0.282. The mass and radius are determined to be M = 9.8 $M_\odot$ and R = 4.6 $R_\odot$. The fairly rapid rotation (v sin i = 150 km $sec^{-1}$) of σ Ori E makes it impossible to determine the microturbulent velocity. The abundances of five elements are determined for $v_t$ = 0 and 10 km $sec^{-1}$. Except for the deficiency of hydrogen, there appear to be no conspicuous abundance anomalies. (auth)

**15011** THE CHEMICAL COMPOSITION OF IOTA HERCULIS. Peters, Geraldine J.; Aller, Lawrence H. (Univ. of California, Los Angeles). Astrophys. J.; 159: 525-42(Feb 1970).

The chemical composition of the sharp-lined B3 V star ι Her has been determined by a model-atmosphere technique. All elements considered in this analysis seem to have solar-type abundances. The effective temperature determined for this star by the criterion of ionization balance is dependent upon whether blanketed or unblanketed model atmospheres are utilized. The former indicate an effective temperature of 17,000°K, whereas the latter indicate 20,000°K. Reliable scanner data, available measurements of ultraviolet flux, and the work of Hanbury Brown et al. favor the lower temperature. The effective temperature of a B3 V star as determined by Hanbury Brown et al. is closer to 17,000°K. The logarithm of the surface gravity is closer to 17,000°K. The logarithm of the surface gravity is near 4.0. (auth)

**15012** STELLAR SPECTROPHOTOMETRY FROM A POINTED ROCKET. Stecher, Theodore P. (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. J.; 159: 543-50(Feb 1970).

A 13-inch telescope with a three-channel photoelectric scanner was successfully flown on an Aerobee rocket. The whole rocket assembly was pointed at four program stars with an absolute accuracy exceeding 20 seconds of arc. Two photometric scans (of 20-sec duration) of each program star were made with a resolution of 10 Å. The observed stars were α CMa, A1 V; ε CMa, B2 II, ζ Pup, O5f; and $\gamma^2$ Vel, WC8. The spectrum of each star is presented in absolute energy units. A preliminary discussion of the spectra is made. (auth)

**15013** ULTRAVIOLET FLUXES AND BOLOMETRIC CORRECTIONS FOR LATE B TO F MAIN-SEQUENCE STARS. Davis, John; Webb, Robert J. (Univ. of Sydney). Astrophys. J.; 159: 551-68(Feb 1970).

A comparison of observed ultraviolet fluxes with the predictions of line-blanketed model atmospheres for stars of spectral type B5 and later has revealed significant discrepancies that increase toward later spectral types. Possible sources of ultraviolet opacity are discussed which are not included in the models but which might explain the discrepancies. Bolometric corrections for existing model atmospheres, based on a clear definition that uses solar data to establish the zero point, are presented. The theoretical values are compared with empirical bolometric corrections computed from the same definition by using combined ultraviolet, visual, and infrared observational data for stars in the spectral range B8 to F5. The empirical bolometric corrections have been used to derive effective temperatures, based entirely on observational data, for five A- and F-type stars for which angular-diameter measurements are available. (auth)

**15014** THE BLUE HORIZONTAL-BRANCH STARS OF M15, M92, M13, AND M3. Newell, E. B. (Australian National Univ., Canberra). Astrophys. J.; 159: 443-57(Feb 1970).

The physical characteristics of blue horizontal-branch stars in the northern globular clusters M15, M92, M13, and M3 are investigated on the basis of Sandage's (1969) UBV observations. These data are interpreted by means of the empirical correlations between broad-band colors and atmospheric parameters found for the blue horizontal-branch stars of NGC 6397 and ω Cen by Newell, Rodgers, and Searle. Use is made also of Sargent's low-dispersion spectra of several stars in M15 and M92. A discussion of the results for the four northern clusters, together with the results previously obtained for NGC 6397 and ω Cen, leads to four principal conclusions, which are discussed. (auth)

**15015** MODELS FOR THE ENVELOPES OF Be STARS. II. Marlborough, J. M. (Univ. of Western Ontario, London). Astrophys. J.; 159: 575-81(Feb 1970).

Hα line profiles are presented for reasonable values of all parameters characterizing the model envelopes described in an earlier paper. Two computational difficulties which arose in that paper are resolved. (auth)

**15016** MOMENTS OF CHANDRASEKHAR'S FUNCTIONS $H_1$ AND $H_r$. Bond, G. R.; Siewert, C. E. (North Carolina State Univ., Raleigh). Astrophys. J.; 159: 731-2(Feb 1970).

The first twenty-two moments of Chandrasekhar's functions $H_1$ and $H_r$ are given. (auth)

**15017** THE LITHIUM ISOTOPE RATIO IN DELTA SAGITTAE. Boesgaard, Ann Merchant (Univ. of Hawaii, Honolulu). Astrophys. J.; 159: 727-9(Feb 1970).

The apparent Li isotope ratio has been determined from measurements of the shift of the center of gravity of the Li doublet at λ6707 on two 4 Å $mm^{-1}$ spectrograms of δ Sge. The $^6$Li content is found to be 12 ± 6% of the total Li. High-energy spallation reactions predict about 30% $^6$Li. The discrepancy can be understood in terms of post-main-sequence dilution. (auth)

**15018** ZEEMAN MEASURES OF SHARP-LINED EARLY B STARS. Conti, Peter S. (Univ. of California, Santa Cruz). Astrophys. J.; 159: 723-5(Feb 1970).

Measures of Zeeman-analyzed spectrograms of early B stars in Orion are presented. There is no evidence that any of the stars studied have detectable fields. These results do not confirm the presence of magnetic fields in these stars reported by Sargent, Sargent, and Strittmatter. (auth)

**15019** A HIGH-DISPERSION VELOCITY CURVE OF U SAGITTARII. Jacobsen, T. S. (Univ. of Washington, Seattle). Astrophys. J.; 159: 569-73(Feb 1970).

A radial-velocity curve based on fourteen high-dispersion coudé spectrograms of U Sgr has been constructed. The amplitude is 41.0 km $sec^{-1}$. The velocity of the system is +3.38 ± 0.19 km $sec^{-1}$. There is a pronounced depression or "hump" of maximum depth about 3 km $sec^{-1}$ at phase 0.58 P. On ten of the spectrograms, interstellar lines of Na I or Ca II were measured at an average velocity of −9.78 ± 0.22 km $sec^{-1}$. Spectra of two cluster members also showed sharp interstellar Na I lines at an average velocity of −9.78 ± 0.33 km $sec^{-1}$. The radial velocity of the cluster as a whole, found from 30 to 40 members by other observers, shows a remarkably close agreement with the systemic velocity of the Cepheid, thus greatly strengthening the case for its cluster membership. (auth)

**15020** INTRINSIC POLARIZATION IN NONGRAY ATMOSPHERES. Collins II, George W. (Ohio State Univ., Columbus, Ohio Wesleyan Univ., Delaware). Astrophys. J.; 159: 583-91 (Feb 1970).

This paper presents a method for solving the problem of polarized radiation arising in a plane-parallel nongray atmosphere from Thomson scattering by free electrons. The results are explicitly applied to the atmospheres of early-type stars. The dependence of the net intrinsic polarization on wavelength and spectral type is explicitly given. It is found that, contrary to earlier studies involving gray-atmosphere calculations, almost no net polarization is to be expected in the visible. However, up to 2 or 3% net polarization is to be expected in the far-ultraviolet. It is concluded either that there is a fundamental error relating to the concept of

the structure of early-type atmospheres or that the observationally determined intrinsic polarization cannot have its origin in the photospheres of these stars. (auth)

**15021** THE DIRECT CALCULATION OF THE H-FUNCTION FOR COMPLETELY NONCOHERENT SCATTERING. Warming, R. F. (Ames Research Center, Moffett Field, Calif.). Astrophys. J.; 159: 593-604(Feb 1970).

The generalized H-function for completely noncoherent isotropic scattering is expressed in terms of a real integral which is admirably suited for computational purposes. The resulting integral is then modified so that it may be evaluated numerically by using Legendre-Gauss quadrature. Six-place tables of the H-function are given for a Lorentz scattering profile and a wide range of the albedo parameter $\omega$. (auth)

**15022** METAL-POOR STARS. I. EVOLUTION FROM THE MAIN SEQUENCE TO THE GIANT BRANCH. Iben, Icko Jr.; Rood, Robert T. (Massachusetts Inst. of Tech., Cambridge). Astrophys. J.; 159: 605-17(Feb 1970).

The evolution of metal-poor stars during early hydrogen-burning phases is described as a function of all composition variables. New Cox-Stewart opacity tables have been used for the pertinent models. Particular attention is paid to (1) the dependence on age and composition of the turnoff characteristics of derived time-constant loci and (2) the dependence on time and on the metal-abundance parameter Z of interior-structure variables. Turnoff surface temperature is found to be a strong function of Z. It is shown that, on the basis of a comparison with observed turnoff colors alone, the relative ages of stars in M13, M3, M15, and M92 cannot be determined to better than several billion years. (auth)

**15023** NUMERICAL STABILITY OF COMPUTATIONS OF STELLAR EVOLUTION. Sugimoto, Daiichiro (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. J.; 159: 619-27(Feb 1970).

The numerical instability arising from the coupling between hydrostatic equilibrium and thermal processes in a star is discussed. Two alternative physical pictures are possible: the heat wave does or does not propagate through the adjacent shells in the star in a given time step (slow or rapid evolution). Correspondingly, one has two alternative approaches to the mathematical formulation. If the physical picture is wrong, a numerical instability is encountered. In practice, different physical pictures are necessary for a model because of a great difference in the time scale of heat conduction between the core and the envelope of the star when an advanced phase of evolution is computed. After analyzing the nature of the instability, it is shown that a single mathematical scheme is possible which always meets the necessary physical picture required by rapid or slow evolution in the stellar core or envelope. In this scheme it is essential that the difference equation for energy flow and the difference equation for energy conservation be off center in opposite directions in the limit of rapid evolution. (auth)

**15024** DIFFERENTIAL ROTATION IN STELLAR CONVECTION ZONES. Busse, F. H. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Astrophys. J.; 159: 629-39(Feb 1970).

The dynamical effects of rotation on thermal convection in a fluid layer of spherical shape induce an equatorial acceleration. Special properties of the convection zone assumed in earlier theories on the differential rotation of the Sun are not required. To demonstrate the mechanism, the mathematical problem of convection in a rotating Boussinesq fluid subject to temperature and gravity fields of spherical symmetry is considered. At the critical value of the Rayleigh number the onset of convection takes place predominantly in the equatorial region. The dynamical constraint of rotation, together with the geometry of the problem, leads to the equatorial acceleration at finite convection amplitudes. Estimates give reasonable agreement with values observed on the Sun. (auth)

**15025** ELECTRICAL CONDUCTIVITY AND CONDUCTIVE OPACITY OF A RELATIVISTIC ELECTRON GAS. Canuto, Vittorio (Goddard Space Flight Center, New York). Astrophys. J.; 159: 641-52(Feb 1970).

The electrical conductivity and the conductive opacity are computed for a system of relativistic degenerate electrons in the presence of a system of ions. In the density-temperature range one is interested, in $10^6 \leq \rho \leq 10^{12}$ (g cm$^{-3}$), $10^5 \leq T \leq 10^{9.5}$°K, the ion-ion interaction is taken into account by means of the pair-correlation function. The numerical values of the electron conduction opacities are given for different values of the parameter $\Gamma$, which characterizes the strength of the ion-ion interaction, and for different values of $2 \leq Z \leq 26$. (auth)

**15026** INFLUENCE OF ION CORRELATIONS ON THE FREE-FREE OPACITY OF STELLAR INTERIORS. Watson, William D. (Massachusetts Inst. of Tech., Cambridge). Astrophys. J.; 159: 653-8(Feb. 1970).

The influence of ion correlations on the free-free contribution to the opacity of stellar interiors is calculated. This effect is found to be of most importance under conditions in which the flow of energy by radiation competes with conduction by degenerate electrons. For example, at the edges of degenerate cores in red giants this is the case. Here the radiative opacity is reduced by roughly 10%. However, in most stellar interiors the usual assumption of an incoherent interaction with the ions is shown to be accurate to within a few percent. The effect on the solar opacity is less than 1%. (auth)

**15027** LONG-PERIOD VARIATIONS IN THE BETA LYRAE SYSTEM. Alduseva, V. Ya. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 653-6(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 832-6(Jul-Aug 1969).

An analysis of the author's 1961-1963 spectrophotometric observations of $\beta$ Lyr and of photoelectric light curves obtained in the 1958-1959 international program reveals long-period variations in the spectral characteristics, shape of the light curve, and integrated brightness of the $\beta$ Lyr system in the photographic spectral region. The period of these variations is found to be P = 1141 days. It is suggested that the source of the variations may be found among the factors responsible for disturbing the orbital motion in the $\beta$ Lyr system. (auth)

**15028** OBSERVATIONS OF EARLY-TYPE STARS IN THE CLUSTER NGC 6913. Raznik, R. M. (Ul'yanovsk Teachers Coll., USSR). Sov. Astron. AJ (Engl. Transl.); 13: 657-9(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 837-9(Jul-Aug 1969).

Photoelectric and spectroscopic observations were made of early-type stars in the cluster NGC 6913. Star No. 2 is suspected of variability. Star No. 3 is probably a binary system (type B0 + A7). The emission star No. 5 is found to vary in brightness and color. (auth)

**15029** METHOD FOR IDENTIFYING HIGH-VELOCITY OB STARS. Pavlovskaya, E. D. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 660-8(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 840-50(Jul-Aug 1969).

A critical analysis is made of the method of Vitrichenko et al. for identifying OB stars of abnormally high velocity from their space velocities. Since the spatial and kinematic characteristics of these stars, which on the average are located at very large distances from the Sun, are determined with low accuracy, the method of Vitrichenko et al. yields an excessive number of high-velocity stars in the directions of galactic longitudes 90° and 270°. When high-velocity stars are discriminated according to their radial velocities they often include spectroscopic binary stars if the radial velocity at an arbitrary point of the orbit is used instead of the $\gamma$ velocity. (auth)

**15030** HYDRODYNAMICAL THEORY OF STELLAR ROTATION. II. STEADY-STATE ROTATION AND MERIDIONAL CIRCULATION. Porfir'ev, V. V. (Kiev Astronomical Observatory). Sov. Astron. AJ (Engl. Transl.); 13: 641-6(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 817-23(Jul-Aug 1969).

A discussion is given of topics concerning steady-state rotation and the existence of meridional circulation in rotating stars. It is shown that if magnetic fields and viscosity are absent, steady-state rotation is possible only if there is no meridional circulation. Expressions describing the circulation-free rotation law are derived. For stars whose mass is less than some critical value ($\approx$10 to 15 $M_\odot$) the rotation law entails a decline in angular velocity toward the surface. For more massive stars the radial dependence of the angular velocity should be opposite in sense, in the case of circulation-free rotation. The basic principles of the theory for meridional circulation in a rigidly rotating star, as developed by Eddington, Sweet, and Mestel, are examined. The underlying assumptions for this theory are shown to contain internal contradictions, thereby leading to incorrect results. It is concluded that the theory is invalid and should be abandoned. Rough estimates are made for the velocity of the meridional circulation arising if the circulation-free rotation law is violated. The circulation velocity will then be much greater than the Eddington-Sweet circulation velocity and of the same order as the (linear) rotational velocity. It is shown that this result at least does not conflict with the observational evidence. (auth)

**15031** RELATIVISTICALLY COVARIANT EQUATIONS FOR THE COUPLING OF RADIATION WITH MATTER. Imshennik, V. S.; Morozov, Yu. I. (Inst. of Applied Mathematics, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 628-34(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 800-9(Jul-Aug 1969).

In a medium moving at relativistic velocities it is important to consider nonequilibrium radiation. In the general case such a physical system is described by the equations of radiational hydrodynamics and the equation of radiative transfer, formulated in a relativistically covariant form. These equations are used to derive moment equations for the radiation, including not only absorption but the scattering of photons by free electrons. The effect of photon scattering in the relativistic case is discussed in detail. The resulting equations can be applied, in particular, to a supernova envelope when traversed by strong shock waves; in this situation the effect of photon scattering can appreciably change the picture from the rough approximation of radiative heat conductivity used previously. (auth)

**15032** INTERFEROMETER OBSERVATIONS OF THE FILAMENTARY NEBULA S22. Lozinskaya, T. A. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 573-9 (Jan-Feb 1970).

Translated from Astron. Zh.; 46: 730-8(Jul-Aug 1969).

A series of observations of the filamentary nebula S22 was conducted with a Fabry–Perot etalon and an electronic image converter. The profiles of the H$\alpha$ and [N II] lines were studied. For individual filaments the half-width of the 6583 Å line corresponds to 27 ± 2 km/sec. The radial velocity of the nebula is found to be –26 ± 6 km/sec from the interferometer observations and –44 ± 15 km/sec from a slit spectrogram (referred to the local standard of rest). The effect of expansion in the nebula is detected; the expansion velocity is found to be 35 ± 2 km/sec. A method is suggested for estimating the distance to supernova remnants having a known expansion velocity. The problem of the nature of S22 is discussed. (auth)

**15033** STABILITY OF STELLAR SYSTEMS OF THE ORION TRAPEZIUM TYPE. Duboshin, G. N.; Rybakov, A. I. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 704-11(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 895-906(Jul-Aug 1969).

A discussion is given of the problem of stability in the Lagrangian sense for a stellar system such as the Orion Trapezium, embedded in an extensive star cluster or cosmic cloud. It is assumed that the stars in the system can be represented by mass points attracting one another in accordance with Newton's law. The influence of the cluster (or cloud) on each star in the system is regarded as reducing the attractive force of a material medium having a definite shape and structure. Cases are considered where the cloud is represented by a homogeneous sphere, an inhomogeneous sphere with a spherical density distribution, and finally, a homogeneous triaxial ellipsoid. For each case the first integrals of the system are set up, a relation analogous to the Lagrange–Jacobi equation is derived, and conditions for stability (necessary) and instability (sufficient) are established. It is shown that if the Orion Trapezium is regarded as embedded in a homogeneous spherical cloud, the necessary condition for stability will be satisfied. (auth)

**15034** LIGHT CURVES OF SUPERNOVAE. Grasberg, E. K.; Nadeezhin, D. K. (Inst. of Applied Mathematics, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 585-6(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 745-6(Jul-Aug 1969).

It is shown that the basic features of the light curves of type II supernovae can be explained by the emergence of a shock wave into the extended atmosphere of a supergiant star having a radius of 5000 to 10,000 $R_\odot$. (auth)

**15035** PLANETARY NEBULAE AS POSSIBLE X-RAY SOURCES. Khromov, G. S. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 587-8(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 747-9(Jul-Aug 1969).

A discussion of known x-ray emission mechanisms indicates that planetary nebulae cannot be observable x-ray sources in the energy range 4 to 8 keV. Statistical considerations imply that to the current accuracy of position determinations for x-ray sources there is a high probability of chance coincidences with planetary nebulae in the vicinity of the galactic equator. On the other hand, it is possible that hot planetary nuclei will be observable in the energy range near 0.25 keV. (auth)

**15036** THE ATMOSPHERES OF TAU SCORPII (B0 V) AND LAMBDA LEPORIS (B0.5 IV). Hardorp, Johannes (Hamburger Sternwarte, Hamburg. Inst. of Theoretical Astronomy, Cambridge, Eng.); Scholz, M. Astrophys. J., Suppl. Ser.; 19: No. 173, 193-233(Feb 1970).

New observations of the continuous and line spectra of $\tau$ Sco and $\lambda$ Lep are reported. These spectra are studied by using model-atmosphere techniques in the LTE approach. Effective temperatures can be safely determined from ionization equilibria and Balmer jumps; surface gravities depend largely on the choice of hydrogen-broadening theories. For $\tau$ Sco, Pfennig's theory and the mass–luminosity relation both point to a value for log g of about 4. The deep cores of H I and strong He I lines are not satisfactorily predicted, probably because the models fail in the uppermost layers. The question of microturbulence is critically examined. Analyses of abundance are carried out with models $T_{eff}$ = 32000°K, log g = 4.1 $\xi$ = 4.5 km $s^{-1}$ for $\tau$ Sco and $T_{eff}$ = 30900°K, log g = 4.05, $\xi$ = 4.5 km $s^{-1}$ for $\lambda$ Lep; Mihalas's unblanketed models are used. Most elements have solar abundances, neon is overabundant, and the cosmic iron abundance should be rediscussed. The wings of diffuse He I lines can be satisfactorily predicted with the abundance deduced from weak lines, if recent broadening theories are applied. The ratio of helium to hydrogen is about 0.10 by number, and its dependence on the choice of model is shown to be small. (auth)

**15037** IMPROVED OPACITY TABLES FOR POPULATION I STELLAR INTERIORS. Watson, William D. (Massachusetts Inst. of Tech., Cambridge). Astrophys. J., Suppl. Ser.; 19: No. 174, 235-42(Feb 1970).

Recent improvements in the calculation of the line contribution to stellar interior opacities are employed to compute Rosseland opacities for ten Population I compositions. Opacities at thirty-eight temperature-density points are presented for each element mixture. The compositions are chosen to provide a basis for interpolation and extrapolation in stellar interior calculations. (auth)

**15038** ROSSELAND OPACITY TABLES FOR POPULATION I COMPOSITIONS. Cox, Arthur N.; Stewart, John N. (Los Alamos Scientific Lab., N. Mex.). Astrophys. J., Suppl. Ser.; 19: No. 174, 243-59(Feb 1970).

Detailed tables of Rosseland mean opacities, without allowance for electron conduction, are presented for ten Population I compositions. These tables provide a basis for interpolation and extrapolation in stellar structure calculations. Changes from the methods employed in previous publications are described. A discussion and calculations concerning the accuracy of the free–free absorption are given. (auth)

**15039** ROSSELAND OPACITY TABLES FOR POPULATION II COMPOSITIONS. Cox, Arthur N.; Stewart, John N. (Los Alamos Scientific Lab., N. Mex.). Astrophys. J., Suppl. Ser.; 19: No. 174, 261-79(Feb 1970).

Compact opacity tables, not including the effects of electron conduction, are given for nineteen Population II mixtures, including four representing advanced stages of evolution. (auth)

**15040** OPEN CLUSTER IC 2581. Evans, T. Lloyd (Radcliffe Observatory, Pretoria). Mon. Notic. Roy. Astron. Soc.; 146: 101-21(1969).

The cluster IC 2581 has the A7 supergiant HD 90772 near its center. Photoelectric and photographic UBV measures of 397 stars within 8′ of HD 90772 are presented. Spectral classifications are made for 10 stars. There are approximately 120 members brighter than V = 15.5, $M_v$ = +2.3. These include two supergiants, an eclipsing binary (HD 90707) and two Be stars, one of them variable. The cluster radial velocity is –3 km $s^{-1}$, $E_{B-V}$ = 0.42m and $(m - M)_0$ = 12.0m. The cluster may be part of the $\eta$ Carinae complex. Early-type stars in IC 2581 and the very similar cluster NGC 457 are well represented by theoretical models for 15 $M_\odot$, with an age of $10^7$ years. The A–F supergiants HD 90772 and $\phi$ Cas, if members of the two clusters, have $M_v \sim -8.6$ and may represent a high-luminosity stage in the evolution of a star of 18 $M_\odot$. Stars with very similar spectra and luminosity occur in the Large Magellanic Cloud. An error in the derivation of the standard zero-age main sequence is discussed. (auth) (UK)

**15041** COLLAPSE OF INTERSTELLAR GAS CLOUDS. IV. MODELS OF COLLAPSE AND A THEORY OF STAR FORMATION. Disney, M. J. (Univ. of Arizona, Tucson); McNally, D.; Wright, A. E. Mon. Notic. Roy. Astron. Soc.; 146: 123-60(1969).

Previously developed numerical methods for the solution of the equations of hydrodynamics with gravitation are applied to a series of cloud models to investigate the roles of heating, cooling, and density distribution on the collapse. A characteristic mode of collapse is found for clouds of all masses. This mode of collapse involves the growth of density in the central parts of the gas and in other regions of increased density. In the regions of density growth, the velocity field is almost linear wave. The effects of opacity are also investigated and it is shown that the increase of opacity with increasing central density is of critical importance for star formation. The behavior of small density perturbations is discussed. It is found that small perturbations grow only under certain conditions of the flow, otherwise they will disperse. A discussion of cloud fragmentation is given in which it is shown that fragmentation is a consequence of nonuniform collapse and is enhanced by the interaction of the atomic properties of the interstellar medium with the dynamics of the problem. A theory of

stellar evolution—from gas cloud to protostar—is proposed and justified both in terms of the numerical models presented and by analytical linear wave flow approximations where appropriate. It is found that the smallest protostars that can be formed by this method have a mass $\sim 10^{32}$ g. A theory of the formation of interstellar gas clouds is also discussed. (auth) (UK)

**15042** IONIZATION STRUCTURE OF PLANETARY NEBULAE. VII. THE HEAVY ELEMENTS. Flower, D. R. (University Coll., London). Mon. Notic. Roy. Astron. Soc.; 146: 171-85(1969).

Computer models of planetary nebulae were developed that incorporate, in addition to H and He, the elements C, N, O, and Ne. The inclusion of the heavy elements has little effect on the radiative transfer problem, because of their relatively low total abundance, and this is therefore solved using the techniques described in Paper III of this series. However, their inclusion is critical to the thermal balance problem because of the contribution of collisional excitation of low-lying terms of ions of the heavy elements to the cooling of the nebula; this is discussed in detail. An example is given of the required input and resultant output of the models. Results of model-atmosphere calculations of the spectral distribution of the radiation from the central stars are now available, and this information may be included as part of the input data. Dynamical effects and small-scale filamentary structure, which may prove to be of importance in real nebulae, are not taken into account. (auth) (UK)

**15043** THEORY OF ROTATING MAGNETIC STARS. Wright, G. A. E. (Univ. of Manchester, Eng.). Mon. Notic. Roy. Astron. Soc.; 146: 197-212(1969).

The problem of a uniformly rotating magnetic star in radiative equilibrium is considered. It is found that in order to maintain radiative balance throughout the star, a magnetic field of $P_1$-type has to be strongly centrally condensed, but that the total magnetic energy is very much less than the centrifugal energy. The evolution of the field in a magnetic star is supposed to proceed by ohmic decay through states of radiative equilibrium, i.e., states without meridian circulation. A minimum flux is found, corresponding to zero surface field, below which no $P_1$-type solution can be found. (auth) (UK)

**15044** ABSOLUTE MAGNITUDES OF MIRA VARIABLES FROM STATISTICAL PARALLAXES. Clayton, M. L.; Feast, M. W. (Radcliffe Observatory, Pretoria). Mon. Notic. Roy. Astron. Soc.; 146: 411-21(1969).

The McCormick proper motions are combined with the available radial velocities to derive absolute magnitudes for Mira variables as a function of period. The uncertainties in the results are estimated. The analysis is carried out both at mean maximum ($M_m$) and at mean light intensity ($M_l$) of the variables. Within the errors the absolute magnitudes vary smoothly with period from ~180 days to ~500 days ($M_m$, from −3.0 to −1.0 and $M_l$ from −1.5 to + 1.0). The shorter period Miras (~130 days) deviate from this period–luminosity relation. They have $M_m$ = 1.6 and $M_l$ = −0.1. (auth) (UK)

**15045** HYDRODYNAMICS OF THE HELIUM FLASH. Edwards, Alan C. (Univ. of Wisconsin, Madison). Mon. Notic. Roy. Astron. Soc.; 146: 445-72(1969).

Time-dependent numerical calculations, based on the conservation equations in difference equation form, are presented for a I $M_\odot$ Pop II star evolving dynamically through its helium flash. With the heuristic method used to calculate time-dependent convection, it is found that the convective core of the star explodes. The central temperature exceeds $10^{9}$°K and, at the time the calculations are halted, of the order of $5 \times 10^{48}$ erg have been deposited in the core. The evolution begins with an oscillation of the core of period 60 seconds imposed on the general expansion. The core cannot expand fast enough and slowly heats up. A composition gradient is formed in the convective core opposed to convection. Finally, the core explodes. Throughout the calculation the total energy is conserved to 1 part in $10^4$. (auth) (UK)

**15046** MEMBERSHIP OF THE COMA STAR CLUSTER. Argue, A. N.; Kenworthy, Cecilia M. (Cambridge Univ., Eng.). Mon. Notic. Roy. Astron. Soc.; 146: 479-88(1969).

A search was made for faint possible members of the Coma star cluster. Proper motions and UBVI colours and magnitudes were measured using a Schmidt telescope. As a result, four new members are suggested, and three suggested by Trumpler rejected. Hence, the conclusion drawn by Artyukhina (1955), that the number of members fainter than Trumpler's limit of $m_{pg} = 12^m$ cannot be upheld, is large; the number probably does not exceed ten. The paper includes comments on the use of the Schmidt as an astrometric telescope. (auth) (UK)

**15047** THE RADIAL VELOCITIES OF 335 LATE B-TYPE STARS. Hube, Douglas P. Mem. Roy. Astron. Soc.; 72: 233-80(1970).

Newly determined radial velocities are presented for 335 stars north and south of the equator. Most of these stars have HD spectral type B8 or B9, and all are listed in the Catalogue of Bright Stars. Individual plate velocities are given along with MK spectral types where available. Previously published radial velocities are listed for comparison with these new results. The spectrograms were obtained and measured at the David Dunlap, Radcliffe, and Dominion Astrophysical Observatories. (auth) (UK)

**15048** GRAVITATIONAL COLLAPSE WITH ASYMMETRIES. de la Cruz, V. (Univ. of Saskatchewan, Regina); Chase, J. E.; Israel, W. Phys. Rev. Lett.; 24: 423-6(23 Feb 1970).

Two idealized collapse models, involving a magnetic dipole and a gravitational quadrupole, are analyzed, treating departures from sphericity as small perturbations. Radiative leakage (largely downwards through the Schwarzschild radius) causes externally observable asymmetries to decay to zero in an oscillatory fashion, with a period of the order of the Schwarzschild characteristic time $2\,Gm/c^3$. These results have significant consequences for astrophysics; they imply in particular that a "black hole" cannot be a source of synchrotron radiation. (auth)

## *Quasi-Stellar, Radio, and X-Ray Sources*

**15049** SUPERCONDUCTING STATE OF NEUTRON STARS. Itoh, Naoki (Kyoto Univ.). Progr. Theor. Phys. (Kyoto); 42: 1478-9(Dec 1969).

More exact results on the possibility of the existence of the superconducting state in neutron stars are presented. The transition temperature and specific heat of the neutrons are calculated. The idea of protons in the superconducting state in neutron stars is explored. (M.H.R.)

**15050** REPLY TO KINMAN CONCERNING 3C 345. Hunter, J. H.; Lue, P. K. (Yale Univ. Observatory, New Haven). Nature (London); 225: 366-7(24 Jan 1970).

Kinman (Nature 224: 565(1969)), in criticism of the author's paper in Nature 223: 1045(1969), claims (a) that the Yale photographic magnitudes of the quasar 3C 345 disagree systematically by 0.25 m with the Lick ~ B magnitudes, (b) that the Yale magnitudes were affected systematically by the hour angle of the object at the time of observation, and (c) that because the reality of the 0.4 m outburst on the night of June 10–11, 1969 was based on a single observation, this should be treated with considerable reserve. A reply is given to each of these criticisms. With regard to (a) this is agreed. Concerning (b) there is strong evidence that an hour–angle effect does not exist. Concerning (c) the reliability of the single observation is discussed. The authors reaffirm their published light curve for the quasar. (UK)

**15051** CAN PULSAR MASSES BE DETERMINED. Sutherland, P.; Baym, G.; Pethick, C.; Pines, D. (Univ. of Illinois, Urbana). Nature (London); 225: 353-4(24 Jan 1970).

It is stated that observation of the time dependence of the pulse repetition frequency of a pulsar after a "starquake" makes possible a determination of the pulsar mass, provided that the type of deformation leading to speedup, as a result of the "starquake," is known. It is assumed that the deformation due to rotation is quadrupolar and that, as a result of the "starquake," the star proceeds from one quadrupolar deformation to a smaller one, so as to relieve the stress built up by the decrease in rotation rate. It is calculated that the Vela pulsar PSR 0833-45 has a mass of 0.21 $M_\odot$, a central density of $2.45 \times 10^{14}$ g/cm$^3$, a radius of 17.4 km, and a crust thickness of 8.4 km, or alternatively the values 0.40 $M_\odot$, $2.9 \times 10^{14}$ g/cm$^3$, 21.5 km, and 10.5 km, according to which equation of state is used. This pulsar hence seems to be a relatively light neutron star. Two other independent determinations of pulsar mass are also stated to be possible from observations following a "starquake," for which calculations will be reported later. (UK)

**15052** UPPER LIMITS ON THE ANGULAR SIZES OF THREE X-RAY SOURCES IN THE SAGITTARIUS REGION. Polucci, G.; Bradt, H. V.; Mayer, W.; Rappaport, S. (Massachusetts Inst. of Tech., Cambridge). Astrophys. J.; 159: L109-13(Feb 1970).

A large-area modulation collimator aboard a sounding rocket was used to study the angular sizes of three galactic x-ray sources (GX 349 + 2, GX 9 + 1, GX 17 + 2) in the Sagittarius region. In each case an upper limit of 120″ was obtained for the full-width angular size. (auth)

**15053** POSITIONS OF X-RAY SOURCES IN THE SAGITTARIUS REGION. Mayer, W.; Bradt, H. V.; Rappaport, S. (Massachusetts Inst. of Tech., Cambridge). Astrophys. J.; 159: L115-20(Feb 1970).

A rocket experiment yielded data concerning the celestial positions and intensities (1.5 to 8 keV) of twelve x-ray sources in the region of Sagittarius. Comparison with data from other experiments yields no clear evidence for gross time variations in the intensity of these sources. (auth)

**15054** POWER SPECTRA OF THE OPTICAL FLUCTUATIONS OF SCORPIUS X-1. Seeds, Michael A. (Indiana Univ., Bloomington). Astrophys. J.; 159: L121-2(Feb 1970).

Power spectra of the optical fluctuations of Sco X-1 are presented for five nights of observations obtained by Sandage, Westphal, and Kristian in 1967. No harmonic features are found in the frequency range from 10 to 360 cycles per hour. (auth)

**15055** OBSERVATIONS OF WATER-VAPOR EMISSION ASSOCIATED WITH INFRARED STARS. Schwartz, P. R.; Barrett, A. H. (Massachusetts Inst. of Tech., Cambridge). Astrophys. J.; 159: L123-7(Feb 1970).

A survey of 134 infrared stars for microwave $H_2O$ emission has resulted in the detection of emission from three new sources: NML Cygni, the Mira variable U Herculis, and the semiregular variable W Hydrae. In all cases the radial velocities of the microwave lines lie between radial velocities of the optical emission and absorption lines of $H_2O$. (auth)

**15056** MASSES OF QUASI-STELLAR SOURCES. Barnothy, Jeno. Astrophys. J.; 159: L133(Feb 1970).

The method proposed by Bahcall and Salpeter to compute the mass of a QSO belonging to a cluster of galaxies is self-contradictory. The authors did not consider the gravitational redshift of heavy objects of small size. (auth)

**15057** UPPER LIMITS ON THE MASSES OF QUASI-STELLAR SOURCES. Bahcall, John N.; Salpeter, E. E. Astrophys. J.; 159: L135-6(Feb 1970).

There are a number of independent methods for estimating upper limits to the masses of quasars. Some of these methods are listed. (W.D.M.)

**15058** THE STURROCK-FELDMAN MODEL OF QUASI-STELLAR SOURCES. Barnothy, J. M. Astrophys. J.; 159: L137-8(Feb 1970).

The influx of matter from intergalactic space, accelerated by the gravitational field of a quasi-stellar object with a mass of $10^{49.8}$ g, is at least four to five orders of magnitude lower than needed to explain the intrinsic luminosity of 3C 273. (auth)

**15059** POSSIBILITY OF ACCRETION BY QUASI-STELLAR OBJECTS. Sturrock, P. A. (Stanford Univ., Calif.). Astrophys. J.; 159: L139(Feb 1970).

An estimate of the rate of accretion by a QSO depends upon the hypotheses on which the calculation is based. (auth)

**15060** PULSAR NP 0532 AND THE INJECTION OF RELATIVISTIC PARTICLES INTO THE CRAB NEBULA. Shklovskii, I. S. (Inst. of Space Research, Moscow). Astrophys. J.; 159: L77-80 (Feb 1970).

The purpose of the present letter is to improve previous calculations and to connect the problem of synchrotron emission from NP 0532 with the general problem of the injection of relativistic particles into the Crab Nebula. (W.D.M.)

**15061** MAGNETIC-DIPOLE ALIGNMENT IN PULSARS. Davis, Leverett; Goldstein, Mark (California Inst. of Tech., Pasadena). Astrophys. J.; 159: L81-5(Feb 1970).

If the explanation of pulsars involves classical magnetic-dipole radiation of a rotating dipole that makes the angle $\psi$ with the rotation axis, the radiation reaction causes $\psi$ to decrease with time and the frequency to approach cos $\psi$ times the current frequency, $n = \nu_{rot}\nu/(\nu_{rot})^2 = 3 + 2\cot^2\psi$. The values of $\nu$ and $\nu_{rot}$ for the Crab pulsar imply $48.4° \leq \psi \leq 131.6°$ and $n \leq 4.66$. (auth)

**15062** PERIOD DISTRIBUTION OF PULSARS. Setti, G.; Woltjer, L. (Columbia Univ., New York). Astrophys. J.; 159: L87-8(Feb 1970).

The assertion that decay of a pulsar magnetic field is needed to provide an explanation for the period distribution is unfounded. (auth)

**15063** THREE PULSARS WITH MARCHING SUBPULSES. Sutton, J. M. (National Radio Astronomy Observatory, Green Bank, W. Va.); Staelin, D. H.; Price, R. M.; Weimer, R. Astrophys. J.; 159: L89-93(Feb 1970).

High time-resolution studies of individual pulses from the pulsars MP 0031, CP 0808, and CP 0834 reveal subpulse structures which systematically march across the average pulse window from one pulse to the next. It is shown that periodic fluctuations in pulse intensities are manifestations of the same phenomenon. (auth)

**15064** EXCESS SURFACE DENSITY OF EXTRAGALACTIC RADIO SOURCES AT 8 GHz. Brandie, G. W. (Univ. of Michigar Ann Arbor). Nature (London); 225: 352-3(24 Jan 1970).

Observations of radio sources at 8 GHz have shown the existence of a class of extragalactic sources with inverted spectra, indicating the presence of separate high-frequency components within the sources. Extragalactic sources varying in flux density and polarisation are found amongst this class of objects, and these sources have been discussed as a possible explanation of the microwave background radiation. In order to determine the proportion of sources with unusual high-frequency spectra a survey was undertaken at 8 GHz with the Michigan 26-m reflector and a wide-band radiometer with a tunnel-diode amplifier, and flux densities were determined; the survey was considered complete only for flux densities > about 1.3 flux units. In the area surveyed (0.79 Sr, comprising >97% of the area between declinations +5° and −4°, with galactic latitudes/$v^{II}$/>150°) 34 radio sources were found with flux densities >1 flux unit, corresponding to 43 ± 7.3 sources per steradian above this limit. An equation is given for the "surface density," of sources stronger than a given flux value at 8 GHz, and it is found that this surface density is $2^{+0.9}_{-0.6}$ times the number expected from a linear extrapolation of low-frequency data, indicating that the source population found in surveys at 8 GHz is markedly different from the population found below 3 GHz. It is concluded that >50% of the sources found at 8 GHz must be members of the inverted-spectrum class, and it is indicated that at microwave frequencies, the population of flat or inverted-spectrum sources begins to outnumber the sources with power-law spectra. Observers at microwave frequencies should therefore not simply extrapolate lower-frequency observations in order to evaluate problems. (UK)

**15065** EVIDENCE OF RADIO LUMINOSITY EVOLUTION OF QUASI-STELLAR RADIO SOURCES. Arakelyan, M. A. (Byurakan Astrophysical Observatory, Armenia, USSR). Nature (London); 225: 358-9(24 Jan 1970).

The evolution of quasi-stellar radio sources has been studied by investigating the relationship between log N and log S, where N is the number of sources with flux density exceeding S, but this method does not distinguish between density evolution and luminosity evolution. It is thought that a differential study of the optical and radio brightnesses of quasars may provide a method for determining the nature of their evolution; density variation would be expressed both in the radio and optical wavelengths, while luminosity evolution may only be shown in the optical brightness. Using the radio and optical luminosities of 4C quasi-stellar radio sources of known redshifts as given in Astrofizika Vol. 5, plots are shown of log radio luminosity at 500 MHz of 65 such sources vs. the dimensionless co-moving volume corresponding to the redshifts, and of log optical luminosity at 2500 Å of 56 sources versus this volume, together with a difference plot, indicating an increase of mean radio luminosity of the most luminous objects with redshift. Mean values of log F(2,500) are tabulated. Effects of incorrect choice of universe model are discussed. It was found that the mean radio luminosity of the most luminous quasi-stellar radio sources is an increasing function of the redshift, while optical luminosity is practically independent of redshift. The rate of radio luminosity evolution may be estimated from the ratios of radio and optical luminosities; but it appears that the optical luminosity does not evolve. (UK)

**15066** DECAMETRIC VARIABILITY OF CAS A AND 3C 84. Bridle, A. H. (Queen's Univ., Kingston, Ont.); Caswell, J. L. Nature (London); 225: 356-7(24 Jan 1970).

Reference is made to the suggestion by Braude et al. (Mon. Not. Roy. Astron. Soc., 143: 301(1969)) that the apparent variability of the decametric radio emission from Cas A and 3C 84 is intrinsic to the sources and it is stated that, if correct, this would have important consequences for theories of radio sources; but it is argued that the reasons offered by these workers for discounting ionospheric phenomena as the cause of the variations may be insufficient. Observations of 3C 84 at 10.03 MHz by the present authors showed no evidence of variability greater than attributable to residual ionospheric effects. These observations, made with the 10.03-MHz array at the Dominion Radio Astrophysical Observatory, are described. It was essential to eliminate the effects of refraction, scintillation, and scattering, which could contribute to the observed variations. It was likely that correlated variations in the intensities of two such dissimilar sources as Cas A and 3C 84 should be the result of ionospheric phenomena. Both scintillation and multiple scattering in the F layer can cause fluctuations in the received signal with a time scale of several seconds; when the fluctuations are not severe, the average received intensities are not systematically reduced, but in extreme conditions they can be reduced by >3dB. It is also stated that the evidence presented by Braude for lack of zenith-

angle dependence of the observed variations, which would be relevant to refraction and scintillation, appears to be invalid on examination of the comparison sources. Similar results were obtained at 22.25 MHz. (UK)

**15067** RELATION BETWEEN THE STOKES PARAMETERS FOR SYNCHROTRON RADIATION AND THE MAXWELL STRESS TENSOR OF THE EMISSION REGION. Molodenskii, M. M. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 625-7(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 797-9(Jul-Aug 1969).

The Stokes parameters are shown to be related to the four components of the Maxwell tensor. An expression is derived for the degree of polarization of the radiation in terms of hydrodynamic quantities (such as the density of inertial forces and the pressure gradient). This expression implies that depolarization is associated with the external forces. In regions where the stress tensor is compensated [$\nabla H^2 = 2(H\nabla)H$] the polarization has nearly its maximum value. This last condition includes potential and force-free fields. Thus the familiar intricate structure of force-free fields is nevertheless so regular that in their integrated properties (including polarization) they do not differ from harmonic fields. (auth)

**15068** POSSIBLE CAUSES OF THE SECULAR INCREASE IN PULSAR PERIODS. Shklovskii, I. S. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 562-5(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 715-20(Jul-Aug 1969).

Gold's hypothesis concerning a mechanism for the secular increase in pulsar periods is criticized. Evidence is presented that strong gravitational radiation could provide such a mechanism in the pulsar NP 0532. The effect of secular increase in period observed for certain other pulsars could arise if they are moving at a high velocity, $\approx 10^8$ cm/sec, which they could have acquired in the course of the supernova explosion due to asymmetry in the ejected envelope. It is concluded that neutron stars may leave the galaxy in which they were formed, so that intergalactic space may now be filled with them. (auth)

**15069** MECHANISM FOR EMISSION OF X RAYS BY A NEUTRON STAR. Bisnovatyi-Kogan, G. S.; Fridman, A. M. (Inst. of Applied Mathematics, Moscow. Inst. of Nuclear Physics, Novosibirsk, USSR). Sov. Astron. AJ (Engl. Transl.); 13: 566-8(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 721-4(Jul-Aug 1969).

It is shown that if gas is accreted by a neutron star the magnetic field in the stream and the dipole field near the star may be of order $10^8$ G. A collisionless shock wave will be formed in which the electrons can have a temperature of $10^{11}$°K and emit x rays by the synchrotron mechanism. (auth)

**15070** EXTENDED IONIZED COMPLEX OF MATERIAL AT THE PERIPHERY OF THE GALAXY. Ariskin, V. I. (Lebedev Inst. of Physics, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 589-92(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 750-4(Jul-Aug 1969).

Observations of the neutral-hydrogen line and the continuum in the region of the Galaxy toward W41 and W42 suggest that there is an extended ionized complex, within which W42 is located, at the periphery of the Galaxy ($r \approx 20$ kpc). It is proposed that the recombination-line emission in the direction of W41 and W42 comes from the vicinity of compact H II regions analogous to those found in W3, W49, and Cygnus X-DR 21. (auth)

**15071** ON H II REGIONS AND PULSAR DISTANCES. Prentice, A. J. R.; ter Haar, D. (Oxford Univ.). Mon. Notic. Roy. Astron. Soc.; 146: 423-44(1969).

Lists of all clusters and associations within 1 kpc of the Sun and all hot O stars and supergiants that do not belong to clusters are given. The radii of the H II regions surrounding these objects are calculated. Statistically, the distribution of stars of a given spectral class not covered so far are found, and the contributions from these stars to H II regions are evaluated. The level of ionization due to cosmic rays to be found in H I regions is discussed. The results are combined to derive from the observed dispersions the distances of pulsars from the Sun. In this evaluation the possibility that the line-of-sight to a pulsar passes through the H II region of one of the objects is considered; this is the case certainly for six pulsars and possibly for another seven. The remaining 24 pulsars are discussed, using the expressions for the statistical contributions from H II and H I regions, taking into account the fall-off in density with height above the galactic plane. It is found that, indeed, most pulsars lie within 1 kpc from the Sun. In fact, of the 36 pulsar distances given, 18 are less than 1 kpc, seven less than 2 kpc (of which two may well lie within 1 kpc), and of the remaining 11, eight may well lie within 1 kpc. The uncertainty in some of the distance determinations lies mainly in the lack of knowledge of the galactic structure at a height of more than about 500 pc from the galactic plane. It is felt that this discussion of possible contributions to dispersion of radio waves may also be useful for investigations other than pulsar distances. As a by-product of these calculations a value of 0.04 $cm^{-3}$ was found as the median value of the electron density in the galactic plane in the neighborhood of the Sun. (auth) (UK)

**15072** PULSAR PERIODS AND RAPID CHANGES IN THE TERRESTRIAL ROTATION RATE: A REPLY. Pfleiderer, J. (National Radio Astronomy Observatory, Green Bank, W. Va.). Nature (London); 225: 437-8(31 Jan 1970).

Reference is made to Maran and Ögelman (Nature, 224: 349 (1969)) who called attention to the influence on observed pulsar periods of a changing Earth rotation period. The present author considers that the estimates of Maran and Ögelman are not entirely correct, as they did not properly distinguish between the time ratio of period change ($\Delta P/P = \dot{P}$) and the uncertainty of a period determination, $\delta P/P$; they gave an estimate of the absolute uncertainty in the determination of the dimensionless quantity P and interpreted this number as relative uncertainty for the period determination. It is stated that it is necessary to distinguish between an absolute period change and a rate of period change. The basic observed quantity for any period determination is the pulse arrival time. If the length of day changes by a fixed amount, then the apparent period during rising or setting time of the pulsar changes, due to a changed Doppler effect, by a fixed amount. A fixed period change has a linearly accumulatory effect on the arrival times, and can therefore be measured with a precision that increases linearly with time. On the other hand, a continuous period change by a fixed rate, which seems to be an intrinsic property of some pulsars, has a linearly accumulating effect on the period and can therefore be measured with a precision that increases with the square of time. Among conclusions reached is that there is little hope of detecting changes in day length <100 ms even with better-timed and more-extended pulsar measurements. (UK)

**15073** CONNECTION BETWEEN PULSARS AND SUPERNOVAE. Prentice, A. J. R. (Oxford Univ.). Nature (London); 225: 438-9(31 Jan 1970).

Some preliminary results of a statistical study of the spatial distribution of pulsars in the Galaxy are reported, which are stated to have direct relevance to the pulsar–supernova hypothesis and to certain features in the observed distribution of pulsar galactic latitudes. Evidence is presented in support of the theory that most pulsars may have been formed in Type-II supernova explosions and possessed extremely high initial velocities (of the order of 1000 km/sec). On this basis four new pulsar-supernova identifications are suggested. It is noted that, so far, only two pulsars have been successfully associated with supernovae. It was found that, of the 16 catalogued supernova remnants within about 2 kpc and the 42 pulsars under investigation, there were nine instances where a pulsar lay within 6° of a remnant site, and distance estimates for pulsars and supernova remnants were compatible. This is stated to be consistent with the hypothesis of intrinsically high pulsar velocities. A minimum speed of 200 km/sec is necessary to explain the complete absence of pulsars inside the older supernova remnant shells. As a test case young pulsar PSR 0833-45 is considered, inside the Type II supernova remnant Vela X, and it is concluded that there is good reason to expect that some of the nine instances mentioned are real pulsar–supernova associations. The ages of the remnants and, independently, those of the suspected pulsars were computed using the PSR 0833-45–Vela X identification as a yardstick, and results are tabulated and discussed. (UK)

**15074** VARIATIONS OF LINEAR POLARISATION IN EXTRAGALACTIC RADIO SOURCES. Aller, H. D. (Univ. of Michigan, Ann Arbor). Nature (London); 225: 440(31 Jan 1970).

It is stated that sources 3C 120, -273, -279, -345, and -454.3 have shown significant changes in polarization and that the sources 3C 84, NRAO 150, and 3C 446 are also suspected of having variable polarization. These findings resulted from monitoring of the linear polarizations of the stronger extragalactic variable radio sources at 8 GHz since 1965, using the Michigan 85-ft paraboloid equipped with a rotating linearly polarized feed horn. The general characteristics of the observed variations are described, and are stated to be consistent with expanding-source-type models; they do not require any special source geometry except that the magnetic fields be relatively well ordered. Two processes that cause variations in polarization are described, which occur as a result of decrease of the absorption depth through the source averaged over all polarization ($\tau_v$) with time. The first process is the change with $\tau_v$ of the intrinsic polarization of a synchrotron source. The second process arises when the orientation of the magnetic field is not constant throughout the emitting region of the source. Both processes are only important where $\tau_v \gtrsim 1$. (UK)

**15075** OBSERVATIONS OF THE STRUCTURE OF RADIO SOURCES IN THE 3C CATALOGUE. III. THE ABSOLUTE DETERMINATION OF POSITIONS OF 78 COMPACT SOURCES. Elsmore, B.; Mackay, C. D. (Mullard Radio Astronomy Observatory, Cambridge, Eng.). Mon. Notic. Roy. Astron. Soc.; 146: 361-79(1969).

Observations have been made with the Cambridge One-Mile telescope of 78 unresolved or slightly resolved radio sources in the 3C catalogue. Absolute positions have been determined for these sources with typical errors of ~1 to 1.5″ arc in R.A. and ~2″ cosec δ arc in declination. Details of possibly associated optical objects are given. (auth) (UK)

**15076** LONG-BASELINE INTERFEROMETER OBSERVATIONS AT 408 AND 448 MHz. II. THE INTERPRETATION OF THE OBSERVATIONS. Clarke, R. W. (Nuffield Radio Astronomy Labs., Jodrell Bank, Eng.); Broten, N. W.; Legg, T. H.; Locke, J. L.; Yen, J. L. Mon. Notic. Roy. Astron. Soc.; 146: 381-97(1969).

Detailed model brightness distributions, deduced from long-baseline interferometer observations at 408 and 448 MHz, are presented for 19 radio sources. Notes on the structure of 14 other sources are also included. The smallest scale structure which can be recognized from the observations is about 0.005 second of arc and it appears that none of the sources is completely unresolved. Upper limits to the internal magnetic fields are given for 12 different components of the sources. Most values lie in the range $10^{-3 \pm 1}$ G. Linear dimensions and equivalent brightness temperatures are also computed. Typical dimensions and brightness temperatures for components with the maxima in their spectra near 400 MHz are 20 to 200 pc and $10^{11}$ to $10^{12.5}$K, respectively. The size of the emitting region in 3C 84 is only about 2 pc. (auth) (UK)

**15077** INTERFEROMETRIC OBSERVATIONS WITH A BASELINE OF 127 KILOMETRES. I. Donaldson, W.; Miley, G. K.; Palmer, H. P.; Smith, H. (Univ. of Manchester, Jodrell Bank, Eng.). Mon. Notic. Roy. Astron. Soc.; 146: 213-19(1969).

This is the first of two papers describing observations made on 46 radio sources smaller than one second of arc with a long-baseline interferometer using a radio link. The frequencies used were 1422, 2694, and 4998 MHz, giving baseline lengths of $0.6 \times 10^6$, $1.1 \times 10^6$, and $2.1 \times 10^6$, respectively. Twenty-three of the sources were observed fully at one or more of the three observing frequencies. In this paper the normalization and calibration procedures are described and the results are given on those sources whose fringe visibilities showed no significant variation with hour angle. Upper limits to the angular diameters of these sources, or their unresolved components, were calculated using a circular Gaussian model. Fringe visibilities are also given for the sources which were observed only briefly at either 1422 or 2694 MHz. (auth) (UK)

**15078** SYNCHROTRON EMISSION AT STRONG RADIATIVE DAMPING. Shen, C. S. (Purdue Univ., Lafayette, Ind.). Phys. Rev. Lett.; 24: 410-15(23 Feb 1970).

The motion and radiation of a relativistic classical charged particle in an intense magnetic field are analyzed when the radiative reaction force is comparable with the Lorentz force. Their significance for cosmic problems, especially the acceleration and radiation of cosmic-ray electrons in pulsars, is discussed. (auth)

**15079** LOW-MODE COHERENT SYNCHROTRON RADIATION AND PULSAR PHENOMENA. Eastlund, B. J. Nature (London); 225: 430-4(31 Jan 1970).

It is stated that information on the properties and distributions of the charges responsible for pulsar emission can be deduced from an appraisal of the coherent synchrotron radiation from an oblique rotator model. (auth) (UK)

## *Solar Phenomena*

**15080** TWO NEW PLASMA INSTABILITIES IN THE SOLAR WIND. Hollweg, J. V.; Volk, H. J. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Nature (London); 225: 441-3(31 Jan 1970).

The LH mode in a hot plasma is considered, propagating in the direction of the average magnetic field; two new instabilities were found for frequencies near the proton gyrofrequency. The first is driven by strong electron thermal anisotropy and the second by strong proton thermal anisotropy in the presence of electron anisotropy, and it is thought that the first may have important consequences for the development of the solar wind. This mode is similar to the low-frequency "firehose" instability but involves only the electron anisotropy. The wavelength is short, and the destabilizing centrifugal force on the electrons is able to overwhelm the cyclotron damping due to the resonant protons. If this instability occurs in the solar wind, it will result in an additional coupling between the electrons and protons, with the result that it can contribute to the proton heating. The case of a hydrogen plasma is analyzed, and the existence of such an instability in the solar plasma is discussed. If this instability exists in the interplanetary plasma there will be a transfer of thermal energy from the electrons to the protons, and this may provide a suitable heating mechanism for the solar-wind protons. The energy passes into the proton motion perpendicular to the magnetic field, which may help to explain why in the solar wind $T_\perp$ is not as small as might be expected on theoretical grounds. The second instability is driven by perpendicular proton temperatures sufficiently in excess of the parallel temperatures, and it is thought that it may be important primarily for laboratory plasmas, although it may occur in the solar wind in local regions. (UK)

**15081** HEATING OF THE SOLAR WIND. Burlaga, L. F.; Ogilvie, K. W. (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. J.; 159: 659-70(Feb 1970).

Examination of observations by Explorer 34 of the bulk speed, temperature, and speed gradients in the solar wind indicates the properties of the solar wind to be highly variable. It is shown that the temperature and speed, when averaged over periods of 3 hours, are connected by the relation $\sqrt{T} = (0.036 \pm 0.003)V - (5.54 \pm 1.50)$. Other measurements are used to indicate that this relation may be valid at all epochs of the solar cycle. Although one-fluid models are not quantitatively consistent with this relation, the two-fluid theory of Sturrock and Hartle gives a consistent temperature corresponding to the very quiet time (low speed) which it represents. Observations at the bulk-speed gradients show heating of the plasma to a temperature above that predicted by the above equation at positive gradients and an absence of additional heating at negative gradients. Most such hot spots are associated with large positive bulk-speed gradients. The dependence of the heating effect upon the sign of the speed gradient indicates that the heating takes place as a result of the collision of plasma streams rather than as a result of the Kelvin–Helmholtz instability. Neither this heating effect nor that due to shocks is a dominant process in raising the proton temperature on a large scale. An attractive means for reproducing the relation shown in the above equation may be by heating close to the Sun ($R < 50\ R_\odot$) as a result of damping of hydromagnetic waves by Barnes's mechanism. Support for this hypothesis is found from measurements of the ratio of helium temperatures to hydrogen temperatures, which indicate a value close to 4, consistent with hydromagnetic heating for the wind as a whole. (auth)

**15082** PROPERTIES OF MOTIONS INSIDE AND OUTSIDE OF FLOCCULI. Gopasyuk, S. I.; Tsap, T. T. (Crimean Astrophysical Observatory, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 725-6(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 923-5(Jul-Aug 1969).

The relationship between the velocity field and the brightness in active and undisturbed regions on the Sun is investigated. The radial velocity and brightness were measured with a magnetograph in the lines λ 5250 Fe I, λ 6103 Ca I, Hα, Hβ, and Ca II $K_3$. The brightest points of flocculi in active regions as well as the bright mottles forming the chromospheric network of the quiet Sun are found to lie along the contour of zero radial velocity or in its immediate neighborhood. (auth)

**15083** ABSORPTION SPECTRUM OF Rb I IN THE VACUUM ULTRAVIOLET. Connerade, J. P. (Imperial Coll. of Science and Tech., London). Astrophys. J.; 159: 695-702(Feb 1970).

A new investigation of the absorption spectrum of Rb vapor in the region 600 to 900 Å has yielded considerable extension of Beutler's early results, and the analysis has been revised. The transitions are listed in terms of a generalized $J_cK$-coupling notation. Some calculations concerning the Rb II spectrum have also been made. Many of the Rb I features observed exhibit large autoionization widths. (auth)

**15084** ABSORPTION SPECTRUM OF Cs I IN THE VACUUM ULTRAVIOLET. Connerade, J. P. (Imperial Coll. of Science and Tech., London). Astrophys. J.; 159: 685-94(Feb 1970).

A new investigation of the absorption spectrum of Cs vapor in the 600 to 900 Å region has resulted in revisions and extension of the early work of Beutler and Guggenheimer. In particular a prominent series has been observed. Transitions are listed in $(j_cK)$ notation; assignments are based on a new analysis of terms from the Cs II spectrum. A comparison between the Rb I and Cs I spectra is made, and two types of two-electron excitation in inner-shell absorption spectra are distinguished. Many features of the Cs I spectrum exhibit very large autoionization widths. (auth)

**15085** RADIOASTRONOMICAL INVESTIGATIONS OF THE DRIFT OF THE INHOMOGENEOUS INTERPLANETARY PLASMA. Vitkevich, V. V.; Vlasov, V. I. (Lebedev Inst. of Physics, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 669-76(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 851-61(Jul-Aug 1969).

The basic results of radioastronomical measurements of the characteristics of the interplanetary plasma from the data of observations in 1966–1967 are reported. The reduction of the observational data is carried out by the similarity method and by correlation analysis. The velocities and directions of motion of the inhomogeneities, their sizes, shape, and orientation in space are obtained. (auth)

**15086** CHROMOSPHERIC FLARES AND PHENOMENA IN THE UPPER LAYER OF AN ACTIVE REGION. II. Slonim, Yu. M. (Astronomical Inst., Tashkent). Sov. Astron. AJ (Engl. Transl.); 13: 551-61(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 679-714(Jul-Aug 1969).

The connection of flares and fast processes with the stationary filaments of an active region is considered. A physical classification of rapid processes, based on the evolution of the magnetic field of the filament, is substantiated. It is shown that loop prominences (APR), and activations of filaments and their gradual disappearances (dissolutions) are caused by the slow annihilation of the filament field, i.e., by a slow expansion of its magnetic envelope. The flares associated with this category of fast processes are of slow or regenerative nature (type C); they appear during the phase of magnetic field increase of a region; they do not reveal any relationship between the width of the Hα line and their area. Flares of type C differ in their nature from the previously considered pulsed flares (type A) which accompany explosions of the magnetic envelopes of the filaments. Evidence is presented attesting to the fact that the C flares are located above the A flares. (auth)

**15087** IDENTIFICATION OF THE $\nu_3$ $NO_2$ BAND IN THE SOLAR SPECTRUM OBSERVED FROM A BALLOON BORNE SPECTROMETER. Goldman, A.; Murcray, D. G.; Murcray, F. H.; Williams, W. J.; Bonomo, F. S. (Univ. of Denver). Nature (London); 225: 443-4(31 Jan 1970).

Since the detection of $HNO_3$ in the atmosphere it has been thought that oxides of nitrogen, such as $NO_2$, should also be present. The most intense vibration–rotation band of $NO_2$ is the $\nu_3$ fundamental, centered at 1618 $cm^{-1}$, near the center of the $\nu_2$ $H_2O$ band. The solar spectrum, as observed from a balloon-borne spectrometer at 30 km, showed a series of weak lines among the well known $H_2O$ lines, and a faint band envelope was observed centered near 1618 $cm^{-1}$. Laboratory spectra of the $\nu_3$ region, taken under a resolution similar to that in the balloon flight, were also examined, and the corresponding portion of the $\nu_2$ $H_2O$ spectrum was recorded for comparison. Results are reproduced. The center of the $NO_2$ band envolope was masked by the $l_{-1} - l_{-1}$ $H_2O$ line, but the $NO_2$ line structure was clearly identified. A weak line at 1,574 $cm^{-1}$ was probably due to $\nu_2$ HDO. (UK)

**15088** EAST-WEST ASYMMETRY IN THE OCCURRENCE OF SOLAR ACTIVITY CENTERS. Trellis, Michel (Observatoire, Nice). Compt. Rend., Ser. B; 270: 122-4(5 Jan 1970). (In French).

The east–west asymmetry previously noticed by many authors in the occurrence of solar activity centers is independent of the latitude at which these centers are formed, and did not change during the last eight solar cycles. (France)

**15089** HIGH-RESOLUTION OBSERVATIONS OF SOLAR MICROWAVE BURSTS. Tanaka, H.; Enome, S. (Nagoya Univ., Toyokawa, Japan). Nature (London); 225: 435-7(31 Jan 1970).

Two examples are described of bursts with double structure observed at the Toyokawa Observatory, using a quick scanning system installed at the 8-cm radio interferometer with baseline 213.28 m. On Jan. 18, 1969 an impulsive burst of the simple type was observed. The one-dimensional brightness distribution at 3.75 GHz is shown, together with a sunspot sketch. There were two radio burst sources $R_1$ and $R_2$, with $R_2$ appearing about 10 sec after $R_1$. Radio and optical data of the burst and associated flare are tabulated. The position of $R_1$ was identified with that of the flare, but there were no detailed flare records for $R_2$ and all that could be said was that it may have been located at or near the corresponding sunspot $S_2$. $R_1$ was unpolarized, but $R_2$ showed 40 to 50% LH circular polarization. The motion of $R_2$ was estimated to have been ~2500 km/sec. The most striking feature about this event was the parallelism of the activities in both radio sources from just before the maximum and later. It was estimated that the distance between the sources was $\sim 1.6 \times 10^5$ km, and the time delay of activities was less than a few seconds. The polarization characteristics of the sources are tabulated. On Dec. 24, 1968 an impulsive burst of simple type followed weak and complex activity, for which similar data to the Jan. 18 burst are shown. This event was similar to the Jan. 18 event in general characteristics, but there were some detail differences; the activity in both sources was not paralleled, and the enhancement rise time was different in both sources. The most interesting point with regard to this burst was that, although there was a flare of importance 2F associated with $R_1$, none was observed for $R_2$, but it may be suspected that the radio burst occurred somewhere in the neighborhood of sunspot $R_2$. The time delay of the start of radio enhancement suggested a disturbance which triggered the microwave burst and propagated from one source to another at $\sim 1.5 \times 10^4$ km/sec. There is, however, no known disturbance with such a velocity, and possible mechanisms considered are hydromagnetic shock waves and effects of high-energy particles. It is suggested, as a working model, that hydromagnetic shock waves accelerate electrons that emit the microwave radiation and heat the magnetic flux tubes between both sources, and that these hot flux tubes may become good channels for the propagation of high-energy electrons. Among conclusions reached is that the problem of the polarization characteristics of solar radio bursts due to the propagation condition is still unsolved. (UK)

**15090** RAPID-SCANNING LOW-NOISE SPECTROMETER FOR STUDY OF SUNSPOT SPECTRA. Blackwell, D. E.; Mallia, E. A.; Petford, A. D. (Oxford Univ.). Mon. Notic. Roy. Astron. Soc.; 146: 93-9(1969).

A rapid scanning high-resolution photoelectric spectrometer designed for the study of sunspot spectra is described. The spectrometer employs an on-line computer for signal integration, and to reject scans that are contaminated by false light due to "seeing." The apparatus is installed at the Gornergrat, Switzerland, at a height of 3090 meters. An example of its performance is given. (auth) (UK)

## Galaxies

**15091** INTERSTELLAR AND ATMOSPHERIC CLOUDS. Evans, G. R. (Univ. of Edinburgh); Penston, M. V. Nature (London); 225: 357-8(24 Jan 1970).

It is stated that a striking similarity exists between the physics of the behaviour of the interstellar medium and that of water vapour in an atmospheric cloud, and the form of the P–V diagram is similar for both. In the interstellar case the P–V relation is derived from the assumption that the heating and cooling processes of the interstellar gas are in balance; at high densities the temperature is low and the gas neutral since the cooling processes, which are two-particle, overwhelm the one-particle heating processes, while at low densities the interstellar medium is hot and ionised for the opposite reasons. In the case of water vapour the PV relation arises more simply since the system behaves as an isothermal van der Waals gas. In both cases a two-phase state exists in equilibrium (high density and low density); in the interstellar case this corresponds to high density, low temperature, neutral interstellar clouds immersed in the low density, high temperature, ionised intercloud medium, while in the atmospheric case it corresponds to water in the form of small droplets in water vapour at saturation pressure. In order to establish this system in water vapour it is first necessary to provide nuclei, either by introduction of small quantities of impurities, as a gas or vapour, or by allowing the vapour to become more than critically supersaturated, under which conditions the impurity arises spontaneously from dissociation of the water molecules and it may be expected that in regions where the interstellar medium is supersaturated small discrete, interstellar clouds are similarly formed in equilibrium with the less dense states. In both cases changes occur that lead to a broad spectrum of masses. The possibility arises that the cloud chamber could be used to check theoretical predictions of the behaviour of the interstellar medium. (UK)

**15092** INTERSTELLAR SOLID HYDROGEN: HOW MUCH AND WHERE. Reddish, V. C. (Royal Observatory, Edinburgh). Nature (London); 225: 367(24 Jan 1970).

The suggestion that hydrogen may freeze onto grains in interstellar clouds is discussed, and it is pointed out that little is known about the physical and chemical properties of solid particles and their surfaces in interstellar conditions of temperature, pressure, and radiation loading. On the other hand it has been shown that the properties of galaxies of stars formed from clouds of solid hydrogen grains would possess features which accord with observation. Although most of the theory propounded may apply also to star formation in clouds of molecular hydrogen, it is desirable to look for more direct evidence for or against the existence of clouds of solid hydrogen grains in the Galaxy, and the question arises as to how much there will be and where to look

for it. The freezing of hydrogen onto the grains will produce pressure instabilities leading to cloud collapse and star formation and cloud lifetimes are discussed. The rate of formation of solid hydrogen will be approximately equal to the rate at which mass condenses to form stars. Star formation seems to occur predominantly in the spiral arms and in aggregates with masses $10^4$ $M_\odot$, such as associations of OB stars. From calculations of the total mass of solid hydrogen in the Galaxy it may be expected that not more than 50 clouds of solid hydrogen grains with such masses will exist in the Galaxy at any one time, and the number may be as low as two. There are at least two methods by which a search may be made for clouds of solid hydrogen grains, the first involving a study of the emission spectrum in the far infrared and microwave region, and the second depending on increase of grain size leading to obscuration of starlight, this obscuration for unit mass at shorter wavelengths (<2 $\mu$m) being a hundred or so times higher after hydrogen has frozen onto the grains than before. (UK)

**15093** THE GALACTIC CONTINUUM SPURS AND NEUTRAL HYDROGEN. Berkhuijsen, E. M. (Leiden Observatory, Netherlands); Haslam, C. G. T.; Salter, C. J. Nature (London); 225: 364-5(24 Jan 1970).

It is stated that no association has so far been found between the features of the galactic continuum radiation known as the "spurs" and the distribution of neutral hydrogen. Contour maps of the peak brightness temperature of profiles of low-velocity neutral hydrogen are available (McGee et al., Austral. J. Phys. 16: 136(1963)), and if the position of the steep outer gradient of the continuum radiation from the North Polar Spur is plotted on these maps, a correlation is apparent. The line of outer gradient coincides with a spur feature in the neutral hydrogen distribution. A similar state of affairs is seen for the outer gradient of the continuum ridge at +10° declination. Surveys by other workers are also discussed. The observed correlation seems to lend support to a supernova origin for the spurs. From optical polarisation studies it has been estimated that the dust associated with the North Polar Spur is situated between 50 and 200 pc of the Sun in the direction $l^{II} = 30°$. This would indicate that the star which could have exploded to form the spur was a member of the Scorpio–Centaurus association. If the North Polar Spur is a supernova remnant, some evidence of the supernova event might be expected; this may be represented by a recently found x-ray star or the runaway star $\xi$ Opkiuchus. (UK)

**15094** COMPACT NONTHERMAL SOURCES IN M87. Burbidge, G. R. (Univ. of California, San Diego). Astrophys. J.; 159: L105-8(Feb 1970).

It is shown that the recently discovered compact nonthermal radio source in M87 may give rise to a powerful x-ray source through the Compton effect. It is also suggested that the evidence for small optical structures in the jet may indicate that the optical radiation and some of the x-ray flux comes from electrons and magnetic fields generated in small dense pulsar-like objects which have been ejected from the nucleus of the galaxy. (auth)

**15095** A LARGE, ASYMMETRICAL LIGHT PULSE FROM THE N GALAXY PKS 0521–36. Eggen, O. J. (Australian National Univ., Canberra). Astrophys. J.; 159: L95-7(Feb 1970).

The N galaxy associated with PKS 0521–36 showed a rapid, 1-mag increase in brightness early in 1969 and a subsequent slow decline. The colors are very similar to those for other N galaxies and are redder than those for QSSs. If the minimum observed colors and magnitude are assumed to represent the underlying galaxy and are combined with those observed for a QSS in outburst, the result matches the colors of PKS 0521–36 at maximum light. (auth)

**15096** YEARLY VARIATIONS OF 3C 120. Usher, P. D. (Pennsylvania State Univ., Philadelphia); Shen, B. S. P.; Wright, F. W. Nature (London); 225: 365-6(24 Jan 1970).

It is stated that the photographic light curve of the Seyfert Galaxy 3C 120 shows a large-amplitude (~1.2 magnitudes) long-term decline in brightness over five consecutive years from 1934/35 to 1939/40. Short-term fluctuations of smaller amplitude (~0.3 to 0.6 magnitudes) with decline times of about 200 days are apparently superimposed on the long-term decline. The question arises as to whether these fluctuations are intrinsic to the source or due to some yearly observational selection effect. It is concluded that the yearly fluctuations are almost certainly intrinsic to the source. (UK)

**15097** ROTATION OF THE ANDROMEDA NEBULA FROM A SPECTROSCOPIC SURVEY OF EMISSION REGIONS. Rubin, Vera C.; Ford, W. Kent Jr. (Carnegie Institution of Washington, D. C. Kitt Peak National Observatory, Tucson, Ariz.). Astrophys. J.; 159: 379-403(Feb 1970).

Spectra of sixty-seven H II regions from 3 to 24 kpc from the nucleus of M31 have been obtained with the DTM image-tube spectrograph at a dispersion of 135 Å $mm^{-1}$. Radial velocities, principally from H$\alpha$, have been determined with an accuracy of ±10 km $sec^{-1}$ for most regions. Rotational velocities have been calculated under the assumption of circular motions only. For the region interior to 3 kpc where no emission regions have been identified, a narrow [N II] $\lambda$6583 emission line is observed. Velocities from this line indicate a rapid rotation in the nucleus, rising to a maximum circular velocity of V = 225 km $sec^{-1}$ at R = 400 pc, and falling to a deep minimum near R = 2 kpc. From the rotation curve for R ≤ 24 kpc, the following disk model of M31 results. There is a dense, rapidly rotating nucleus of mass M = $(6 \pm 1) \times 10^9$ $M_\odot$. Near R = 2 kpc, the density is very low and the rotational motions are very small. In the region from 500 to 1.4 kpc (most notably on the southeast minor axis), gas is observed leaving the nucleus. Beyond R = 4 kpc the total mass of the galaxy increases approximately linearly to R = 14 kpc, and more slowly thereafter. The total mass to R = 24 kpc is M = $(1.85 \pm 0.1) \times 10^{11}$ $M_\odot$; one-half of it is located in the disk interior to R = 9 kpc. In many respects this model resembles the model of the disk of our Galaxy. Outside the nuclear region, there is no evidence for noncircular motions. The optical velocities, R > 3 kpc, agree with the 21-cm observations, although the maximum rotational velocity, V = 270 ± 10 km $sec^{-1}$, is slightly higher than that obtained from 21-cm observations. (auth)

**15098** HIGH-VELOCITY GAS MOTIONS IN GALACTIC NUCLEI. Weedman, Daniel W. (Univ. of Texas, Austin). Astrophys. J.; 159: 405-13(Feb 1970).

Observations at 28 Å $mm^{-1}$ of sixteen galaxies showing nuclear emission lines are used to study the gas motions in the galactic nuclei. The galaxies observed include ten galaxies found by Markarian to have strong emission lines, four nearby spirals with unusually blue nuclei as noted by Tifft, and M51 and NGC 4151. Four galaxies are shown to have broad, asymmetric forbidden lines in their nuclei, with profiles similar to those in the Seyfert galaxy NGC 1068. An apparently normal galaxy, NGC 4569 in the Virgo Cluster, is found to have nuclear emission lines that are blueshifted by 1300 km $sec^{-1}$ from the radial velocity of the galactic disk, and the forbidden lines are significantly broader than those in the Seyfert galaxy NGC 4151. The conclusion is reached that the gas velocities indicated by the forbidden-line widths in the nuclei of objects like NGC 4151 are not restricted to galaxies with intense emission lines. (auth)

**15099** THE M87 JET. II. TEMPERATURE, IONIZATION, AND X-RADIATION IN A SECONDARY-PRODUCTION MODEL. Felten, J. E. (Univ. of California, San Diego); Arp, H. C.; Lynds, C. R. Astrophys. J.; 159: 415-23(Feb 1970).

Recent photographs of the M87 jet are presented and discussed. A filamentary protuberance from the end of the jet is visible. The bright emitting regions are very small; they occupy at most a solid angle of 6 square seconds of arc. Data on the small sizes of the knots and the lack of spectroscopically observed emission lines are used to examine a theoretical model of the jet in which the optical electrons are continually regenerated by cosmic-ray protons confined to the optical knots. Heating, cooling, and ionization are discussed. If the time scale of the knots is to be as long as $10^5$ years, they must contain a large mass of gas ($n \sim 400$ $cm^{-3}$, $M \sim 3 \times 10^7$ $M_\odot$) to maintain themselves against disruption by the cosmic-ray pressure. Observational results to date put some restrictions on the model, particularly on the gas temperature, but because of gaps in the data the model cannot be excluded. Certain further observations are suggested, and their value is discussed. (auth)

**15100** MAGNITUDES AND COLORS OF GLOBULAR CLUSTERS IN THE FORNAX SYSTEM. de Vaucouleurs, G. (Univ. of Texas, Austin); Ables, H. D. Astrophys. J.; 159: 425-33(Feb 1970).

Five independent series of photoelectric observations of four globular clusters in the Fornax dwarf elliptical galaxy prove that the U–B, B–V colors are normal and match closely those of the bluest globular clusters in the Galaxy. The average colors $\langle B-V \rangle = +0.67 \pm 0.01$, $\langle U-B \rangle = +0.05 \pm 0.02$, agree with the integrated colors of the Galaxy $(B-V) = +0.63 \pm 0.08$, $(U-B) = +0.08 \pm 0.15$ measured earlier. The mean metallicity index $Q = (U-B) - 0.72(B-V)$ is −0.43, and $(B-V)_0 - Q = 1.05 \pm 0.02$; for the Fornax System as a whole $Q \simeq -0.04$ and $(B-V)_0 - Q \simeq 1.0 \pm 0.1$. Both figures are in close agreement with the blue-limit values deduced by van den Bergh for globular clusters in the Galaxy and M31. The brightest cluster, No. 3, has $m(V) \leq 12.5$, $M_V \leq -8.65$; the faintest, No. 2 has $m(V) = 13.6$, $M_V = -7.55$, if the apparent distance modulus is 21.15. The effective (half-power) diameter of the largest cluster, No. 2, is $0'.35 \pm 0'.05 = 16 \pm 2$ pc at the adopted distance $\Delta = 160$ kpc. (auth)

**15101** BRIGHTEST STAR CLUSTERS IN GALAXIES AS DISTANCE INDICATORS. de Vaucouleurs, G. (Univ. of Texas, Austin). Astrophys. J.; 159: 435-41(Feb 1970).

Photometric data on the brightest star clusters in eight galaxies of the Local Group covering a large interval of absolute magnitudes (−21 to −12) demonstrate the existence of a correlation between the absolute magnitude M(1) of the first-ranked cluster and the total absolute magnitude M(G) of the galaxy. An application to the recent data of Racine and Sandage on the brightest star cluster in M87, the brightest galaxy in the Virgo cluster, leads to a revised value of the Hubble constant H = 50 km $sec^{-1}$ $Mpc^{-1}$, which is less than half the value derived in other recent studies of different distance indicators. An estimation is made of the probable magnitude of the similar size-of-sample effect expected in the first-ranked galaxy in clusters of galaxies. (auth)

**15102** NATURE OF THE FAR-INFRARED RADIATION OF THE GALACTIC CENTER. Lequeux, James (California Inst. of Tech., Pasadena). Astrophys. J.; 159: 459-62(Feb 1970).

The strong far-infrared emission discovered at the galactic center by Hoffmann and Frederick is shown to be probably emission by dust particles; the large total mass of these particles suggests that the mass of the interstellar medium at the center of the Galaxy may be larger than indicated by observations of the 21-cm line. (auth)

**15103** FORCED SPIRAL STRUCTURE IN A UNIFORMLY ROTATING DISK OF GAS. Simkin, Susan M. (Columbia Univ., N. Y.). Astrophys. J.; 159: 463-71(Feb 1970).

It is demonstrated in a linear analysis that a uniformly rotating infinite disk of gas in equilibrium, when disturbed by a gravitating particle moving supersonically about its center, will develop two spiral density waves which are coherent on a large scale. (auth)

**15104** RELATIVISTIC EVOLUTIONARY STAGE OF STELLAR SYSTEMS, INCLUDING INELASTIC COLLISIONS. Podurets, M. A. Sov. Astron. AJ (Engl. Transl.); 13: 618-24(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 787-96(Jul-Aug 1969).

An analysis is made of the relativistic evolutionary stage of stellar systems resulting from inelastic collisions between stars. The rate of thermal relaxation is slower during the late evolutionary stages, so that the distribution function for the particles in the stellar gas (stars) in phase space differs from an equilibrium distribution. In order to find the distribution function the kinetic equation must be integrated. A method based on the theory of adiabatic invariants is described for materially simplifying the kinetic equation. A complete system of equations and additional conditions (within the scope of general relativity theory) is formulated to describe the system of stars together with a central gaseous nucleus in the course of its evolution. (auth)

**15105** POSSIBLE CAUSE OF THE IRREVERSIBILITY IN ROTATING STELLAR SYSTEMS WITH NO STAR–STAR ENCOUNTERS. Pomagaev, S. G. (Inst. of Astrophysics, Dushanbe, USSR). Sov. Astron. AJ (Engl. Transl.); 13: 635-40(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 810-16(Jul-Aug 1969).

A derivation is given of the kinetic equation describing the variation in the stellar peculiar-velocity distribution function in rotating stellar systems under the action of arbitrary unstable gravitational-field fluctuations distributed randomly in space. The diffusion of stars in velocity space is shown to be accompanied by an increase in the peculiar-velocity dispersion and in the entropy of the stars, as well as by an approach of the stellar velocity distribution function to its statistical-equilibrium value. The kinetic equation is solved for the cases of high and low stellar velocities. (auth)

**15106** MOTION OF THE INTERSTELLAR MEDIUM UNDER THE ACTION OF A NOVA OR SUPERNOVA ENVELOPE. D'yachenko, V. F.; Imshennik, V. S.; Paleichik, V. V. (Inst. of Applied Mathematics, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 580-4(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 739-44(Jul-Aug 1969).

A discussion is given of the problem of the motion of the interstellar medium under the action of an envelope thrown off in the explosion of a star (a nova or supernova). The two-fluid system of Navier–Stokes equations for a fully ionized hydrogen plasma is solved numerically. A calculation of this kind enables one to describe the initial phase of the motion of the medium and the process of shock-wave formation. The stellar envelope is modeled by a spherical piston expanding at constant velocity. It is shown that the computed behavior of the motion is apparently realized for slow novae such as Nova Herculis 1934. For supernova envelopes as well as fast novae it is concluded that considerable deceleration of the envelope takes place before the gas-dynamical approximation becomes valid. (auth)

**15107** PURELY DISCONTINUOUS RANDOM PROCESSES IN AN IRREGULAR FORCE FIELD. I. Petrovskaya, I. V. (Leningrad State Univ.). Sov. Astron. AJ (Engl. Transl.); 13: 647-52 (Jan-Feb 1970).

Translated from Astron. Zh.; 46: 824-31(Jul-Aug 1969).

The variation that irregular forces in a stellar system induce in certain parameters of a star's motion, such as the orbit integrals or the absolute value of the velocity, is treated as a purely discontinuous random process. The Kolmogorov–Feller equations describing this process are given, with allowance for an absorbing screen (a critical velocity). The case where the absolute value of a star's velocity varies in an irregular field with no regular field present is examined in detail. (auth)

**15108** PROPERTIES OF THE NUCLEUS OF THE RADIO GALAXY NGC 1275 (PERSEUS A). Dibai, E. A. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 569-72(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 725-9(Jul-Aug 1969).

The conditions in the nucleus of the radio galaxy Perseus A are analyzed on the basis of optical and radio evidence. The following conclusions are drawn: (1) The fine structure of the emission-line profiles indicates an asymmetric dispersal of gas in the inner portions of the nucleus. Evidently two individual clouds are observed, one having no radial velocity relative to the stellar population of the galaxy, the other approaching the observer at a certain angle with a radial velocity of −600 km/sec. The masses of the clouds are 100 and 200 solar masses respectively; the effective expansion velocities are ±200 and ±500 km/sec. (2) The characteristic size of the entire system is $\approx 10^{18}$ cm; its characteristic lifetime is ≈300 yr. (3) The region of dispersing gas apparently agrees with the variable young radio source described by Dent. (4) If the kinetic-energy density of the gas is equal to the magnetic-energy density, the field strength will be ≈1 G. (5) The spatial inhomogeneity of the gas (porosity, or volume filling factor) is of the order of several units, while in the outer parts of the nucleus it is $\approx 10^5$. It is concluded that this quantity increases with time as the hydrodynamic pattern of the explosion develops. This result agrees with Layzer's theoretical ideas, in which initially entangled lines of force tend to unroll in space when a magnetoplasma configuration explodes. (auth)

**15109** H II ZONES IN THE CENTRAL REGIONS OF NINE NORMAL GALAXIES. Pronik, I. I. (Crimean Astrophysical Observatory, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 593-7(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 755-61(Jul-Aug 1969).

Spectra of the central regions of eight normal galaxies have been obtained with fast spectrographs at the 2.6-m telescope of the Crimean Astrophysical Observatory. The measured equivalent widths $W_{H\alpha}$ of the Hα emission line exhibit a correlation with the color index of the central regions of the galaxies. A comparison of $W_{H\alpha}$ for Seyfert and normal galaxies shows that if the color index is the same $W_{H\alpha}$ is about two orders of magnitude greater for Seyfert galaxies. (auth)

**15110** POSSIBLE EXPLANATION FOR THE RING STRUCTURE IN DISK GALAXIES AND THE PROBABLE CHARACTER OF THE SPIRAL AND RING STRUCTURE NEAR THEIR CENTERS. Marochnik, L. S.; Ptitsyna, N. G. (Inst. of Astrophysics, Dushanbe, USSR). Sov. Astron. AJ (Engl. Transl.); 13: 598-607 (Jan-Feb 1970).

Translated from Astron. Zh.; 46: 762-74(Jul-Aug 1969).

Arguments are given for the possible coexistence in disk galaxies of trailing (T) and leading (L) arms, representing spiral density waves of stars and gas. It is shown that superposition of T and L waves in an infinitesimally thin disk may lead to the generation of standing waves in the form of a system of continuous or "granular" rings. Coexistence of spiral and ring structure is also possible. Spiral and ring density waves of stars and gas, not distorted by differential rotation, can also exist in a self-gravitating cylinder homogeneous with respect to z (an alternative to an unfinitesimally thin disk), but the dispersion law will differ from that for waves in an infinitesimally thin disk. In both limiting cases (disk and cylinder) the spiral-wave solutions at the center of the system have bar-like singularities of the same order, which can be realized if the unperturbed density is also singular at the center. The results obtained agree qualitatively with observational data for ring and spiral–ring galaxies. (auth)

**15111** PROBABILITIES FOR RADIATION AND PREDISSOCIATION. II. THE EXCITED STATES OF CH, CD, AND $CH^+$, AND SOME ASTROPHYSICAL IMPLICATIONS. Hesser, James E.; Lutz, Barry L. (Princeton Univ. Observatory, N. J.). Astrophys. J.; 159: 703-18(Feb 1970).

Decay rates determined from data on absolute phase shift versus frequency are presented for the A $^2\Delta$, B $^2\Sigma^-$, and C $^2\Sigma^+$ states

of CH, as well as for the B $^1\Delta$ state of $CH^+$. The spectra were produced by electron-beam excitation of low-pressure $CH_4$ and $CD_4$ gases. Results for the radiative lifetimes of the A and B states of CH support the recent findings of Fink and Welge. For the C $^2\Sigma^+ - X\ ^2\Pi$ transition of CH and CD, the phase data are shown to represent quantitative measures of predissociation probabilities. Higher-resolution spectrograms are used to specify a simple model for the observed phase shifts in which the $F_1$ spin components predissociate about 3 times faster than the $F_2$ spin components. Since, as shown by the new data, nearly every photon absorbed in a line terminating in C $^2\Sigma^+$ results in the photodestruction of CH, the formation rates of CH in interstellar space must be significantly increased to account for the observed intensities. It is also pointed out that the lack of agreement between calculations of the solar G-band intensity and equivalent-width measurements is not due to uncertainties in the molecular constants. (auth)

**15112** SEYFERT GALAXIES. Oke, J. B.; Sargent, W. L. W. (California Inst. of Tech., Pasadena). Sci. J.; 78: No. 6, 57-61 (Feb 1970).

At the center of some galaxies lies a tiny nucleus in a state of violent activity. Its energy is produced by an unknown process, probably the same one which drives the quasars. Understanding it may call for a totally new conception of the laws of physics. (UK)

**15113** HYDROMAGNETIC STABILITY OF A GALACTIC SLAB WITH HALO. Aggarwal, Meera; Talwar, S. P. (Univ. of Delhi). Mon. Notic. Roy. Astron. Soc.; 146: 187-96(1969).

The problem of stability of a slab of an ideal hydromagnetic, self-gravitating liquid of uniform density embedded in a uniform outside medium is investigated, using the normal-mode technique. The outside self-gravitating medium is approximated as either a perfect conductor of electricity or as an insulator. Two models of magnetic field are studied, namely a uniform field normal to the galactic slab and an orthogonal field geometry where the outside magnetic field is assumed equal but normal to the uniform field within the slab confined in its plane. Stability criteria are derived and the critical size of fragmentation of the slab determined in each case. It is found that the presence of the outside gravitating medium has a stabilizing influence in that it decreases both the growth rates and the range of unstable wavenumbers. The magnetic field in each case diminishes the growth rates as well as the critical limit of unstable modes. Further it is found that a magnetic field normal to the galactic slab is very much more effective in stabilization than an equal field confined to the plane of the slab. (auth) (UK)

**15114** NUMERICAL EXPERIMENTAL CHECK OF LYNDEN-BELL STATISTICS. II. THE CORE-HALO STRUCTURE AND THE ROLE OF THE VIOLENT RELAXATION. Cuperman, Sami (Tel-Aviv Univ., Israel); Goldstein, Shyke; Lecar, Myron. Mon. Notic. Roy. Astron. Soc.; 146: 161-9(1969).

In a previous paper, Lynden-Bell's statistical mechanics of collisionless stellar systems was checked by numerical experiments on four initial configurations of a one-dimensional self-gravitating system. Three of the configurations reached a final state that differed from the predicted one: a relatively small fraction of the particles formed a high-energy halo (which contained most of the energy of the system) around a strongly degenerate, low-energy core (which contained most of the particles). In the present experiment the core-halo structure appearing in all four configurations considered was investigated; in addition, the fourth configuration was continued to a final state, and it was the state predicted by the statistics. A detailed analysis of the particle trajectories showed that the configuration that reached the predicted final state, and one of those that did not, relaxed equally as violently. The other two configurations, by comparison, relaxed weakly. This limited experimental evidence does not support a strong correlation between the violence of the relaxation and the satisfaction of Lynden-Bell's statistics. (auth) (UK)

## Cosmology

*Refer also to abstracts 15175, 15176, 15539, and 15633.*

**15115** RELATIVISTIC THERMODYNAMICS. Hamity, Victor H. (Syracuse Univ., N. Y.). Phys. Rev.; 187: 1745-52 (25 Nov 1969).

It is shown that a generalized formulation of statistical mechanics provides a unified logical basis for the construction of a manifestly covariant theory of relativistic thermodynamics in contrast to heuristic approaches, such as the original theory by Planck and Einstein, and more recent ones by Ott and Møller. The generalized formalism is applied to discuss the relativistic thermodynamics of blackbody radiation, including such processes as the absorption and reflection of a light beam as well as the adiabatic cooling of cosmic blackbody radiation in Milne's model of the Universe. The measurement of the temperature of a light beam is also discussed. (auth)

**15116** FINITE-DENSITY NONHOMOGENEOUS NEWTONIAN COSMOLOGIES. Mjolsness, R. C. (Pennsylvania State Univ., University Park). Phys. Rev.; 187: 1753-61(25 Nov 1969).

Approximate self-consistent solutions are obtained to the coupled Vlasov and Poisson equations for a system of self-gravitating point masses subject to a general nonuniform, but spherically symmetric, initial condition. The method of solution, which is essentially the variational determination of a trial distribution function by the application of Hamilton's principle to the trial Lagrangian, is capable of interesting generalization, but, as used here, does not allow for the escape of mass. The model describes cosmologies, or evolving star clusters, in which the usual cosmological principle is modified: isotropy and homogeneity are approximate symmetries in the interior of the system only, while, to present approximation, the Hubble law is still exact. The model agrees with the major observational results of homogeneous isotropic cosmologies, but differs from them in predicting finite (infinite) oscillations of the central density $\rho(0)$ in the gravitationally bound (unbound) case and, in all cases, a finite maximum density $\rho(0)_{max}$. The equation for $\rho(0)$ is that of the average density in homogeneous, but not isotropic, rotating cosmologies. The value of $\rho(0)_{max}$ is constrained observationally only by a requirement of compatibility with the 3°K blackbody radiation, which yields the lower limit $\rho(0)_{max} \gtrsim 10^{-21}$ g cm$^{-3}$. (auth)

**15117** COSMOLOGY: A SEARCH FOR TWO NUMBERS. Sandage, Allan R. Phys. Today; 23: No. 2, 34-41(Feb 1970).

It is postulated that precision measurements of the rate of expansion ($H_0$) and the deceleration ($q_0$) of the Universe may soon provide a major test of cosmological models. Major discoveries of the 1960's are briefly reviewed along with the changes that have come about in $H_0$ since the 1930's. On-going programs to further refine the values of $H_0$ and $q_0$ are discussed. (W.D.M.)

**15118** INTENSITY OF THE SOFT X-RAY BACKGROUND FLUX: REPLY TO BOWYER AND FIELD. Henry, R. C.; Fritz, G.; Meekins, J. F.; Friedman, H.; Byram, E. T. (Naval Research Lab., Washington, D. C.). Nature (London); 225: 362-3(24 Jan 1970).

A reply is made to Bowyer and Field (Nature 223: 573(1969)) who disputed the diffuse background flux of soft x rays reported by the authors (Astrophys. J. Lett. 153: L11(1968)). A further communication by Bowyer and Field is included. (UK)

**15119** COSMOLOGICAL THEORY OF GRAVITATION. Prokhovnik, S. J. (Univ. of New South Wales, Sydney). Nature (London); 225: 359-61(24 Jan 1970).

Reference is made to the author's model of a uniformly expanding Universe in terms of a family of mutually receding galaxies and associated fundamental observers (Proc. Camb. Phil. Soc. 60: 265(1964)). It has been shown that this model is consistent with the operation of Einstein's principles and of relativistic phenomena in the Universe, and that it manifests a cosmological acceleration field resulting from the time dependence of its basic substratum. It is now postulated that this acceleration factor affects the motion of any material particle or of radiation, and it is shown that a body moving with a given velocity past a fundamental observer will pass every fundamental observer in its path with the same velocity, and it will, like radiation and in the absence of any other effects, move with constant velocity relative to the expanding cosmological substratum, hence implying a subtle modification of Newton's first law of motion. The acceleration consists of two parts, one of which is direction oriented and is the acceleration which affects any movement of particles or radiation due to expansion of the substratum. This effect may explain the apparent slow dispersion of galactic clusters in contravention of the virial theorem. The other part is due to the diminution of the velocity vector with time, and represents a very small effect, applying equally for all directions in space, with a zero net effect; it decreases with time and with the density of matter. Gravity and inertia emerge as universal phenomena related to the quantity, distribution and large-scale behavior of matter in the Universe in accordance with Mach's principle. Field modifications caused by a change in a body's position or mass-energy composition travel through the substratum with the velocity of light and movement of the body generates a flow of energy to modify the field. This postulates the existence of gravitational waves traveling with the velocity of light and associated with any change in the mass-energy of a body or of its position relative to the substratum, as required by special relativity. The mathematical description of a field affected by gravitational waves of finite velocity requires the employment of retarded potentials. (UK)

**15120** HYPOTHESIS OF COSMOLOGICAL MAGNETIC INHOMOGENEITY. Zel'dovich, Ya. B. (Inst. of Applied Mathematics, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 608-11(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 775-8(Jul-Aug 1969).

The hypothesis of primordial magnetic disturbances is compatible with the predictions of an isotropic cosmological model concerning nuclear reactions. Magnetic fields of up to $10^{-7}$ gauss are admissible at the present epoch. An inhomogeneity in the magnetic fields can induce an inhomogeneity of the mass density of an order sufficient for galaxies and clusters of galaxies to have become isolated by the present time. (auth)

**15121** ELECTRONS AND PHOTONS IN AN EXPANDING UNIVERSE. Rozental, I. L.; Shukalov, I. Sov. Astron. AJ (Engl. Transl.); 13: 612-17(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 779-86(Jul-Aug 1969).

A discussion is given of the conditions for the formation and propagation of the electrons and hard photons (x rays and $\gamma$ quanta) in an expanding universe. The propagation of the electrons is investigated by solving the invariant kinetic equation. A comparison of the observational and computational results provides an approach for determining some of the parameters of the Universe: the mean density of matter, the evolution and epoch of origin of the cosmic-ray sources, and the intensity of cosmic rays in the Universe. (auth)

**15122** REDUCTION OF THE MASS DEFICIT IN CLUSTERS OF GALAXIES BY MEANS OF A NEGATIVE COSMOLOGICAL CONSTANT. Forman, William R. (Haverford Coll., Pa.). Astrophys. J.; 159: 719-22(Feb 1970).

It is shown that values of the cosmological constant between 0.0 and $-1.0 \times 10^{-34}$ $sec^{-2}$ will reduce the mass deficit for clusters of galaxies and will not conflict with observed values of the deceleration parameter $q_0$ or with derived values of the age of the Universe. (auth)

**15123** MEASUREMENT OF PRIMORDIAL HELIUM ABUNDANCE FROM THE STAR $\mu$ CASSIOPEIAE. Hegyi, Dennis; Curott, David (Princeton Univ., N. J.). Phys. Rev. Lett.; 24: 415-18(23 Feb 1970).

A measurement of the separation between the components of the binary star $\mu$-Cassiopeiae to yield the stellar masses has been made. Applying the mass–luminosity law, a helium abundance $Y \sim 0$ was found where a 1 "$\sigma$" and 2 "$\sigma$" random error allows, respectively, $Y \sim 0.05$ and $Y \sim 0.34$. The measured abundance places an upper limit on the helium production in a big bang cosmological model. (auth)

### *Planetary Phenomena*

*Refer also to abstract 15676.*

**15124** CHEMICAL HOMOGENEITY OF GROUPS OF TERRESTRIAL PLANETS. Jamieson, J. C.; Smith, J. V. (Univ. of Chicago, Ill.). Nature (London); 225: 354-6(24 Jan 1970).

Reference is made to McCrea (Nature 224: 28(1969)) who argued that the near equality of the densities of a combined Mercury–Venus aggregate with an Earth–Mars–Moon aggregate indicates that the two bodies should have effectively identical chemical composition, and because the densities of the individual planets correlate neither with their mass nor distance to the Sun McCrea argued that the near equality of densities strongly support Lyttleton's breakup theory of planetary formation. The present authors state that although McCrea recognized the effect of compressibility he did not calculate its effect on the density; this effect is estimated in the present communication. All chemically reasonable assumptions lead to major reductions of uncompressed density for the more massive planets. Although Lyttleton's theory of rotational breakup of parent planets may be correct, it is not believed that the densities of the terrestrial planets provide a "compelling argument in support of this process of formation." McCrea recognized that the formation of planets involves complex chemical processes, but argued that intermediate bodies should have identical chemical compositions. This assumption need not be correct if the massive radiation and particle output of the Sun causes major spatial differentiation of material surrounding it. Furthermore, chemical differentiation depends so critically on temperature, the gravitational field, atmospheric ionization and other factors that it seems unwise to assert confidently that the variety of masses and densities of the terrestrial planets can result from a common supply of raw material only by rotational breakup of intermediate bodies. A reply from McCrea is included. (UK)

**15125** CHARACTERISTICS OF JUPITER'S DECAMETRIC RADIO SOURCE MEASURED WITH ARC-SECOND RESOLUTION. Dulk, George A. (Univ. of Colorado, Boulder). Astrophys. J.; 159: 671-84(Feb 1970).

Long-baseline measurements of Jupiter's decametric radiation at 34 MHz were made with an intensity interferometer between Boulder, Colorado, and Clark Lake, California (120000 $\lambda$), and with a phase interferometer between Boulder and the Arecibo Ionospheric Observatory (487000 $\lambda$). Theory and observations show that intensity and phase interferometers work equally well for the type of radiation observed. On time scales of less than 0.1 second, the radiation received at the two ends of the baselines was highly correlated, giving an upper limit to the size of an incoherent source of 0.1″, or 400 km, at Jupiter. The observations also imply an upper limit to a possible coherent source of 1″, or 4000 km; this limit results from measuring the time history of the radiation at the two stations, i.e., the radiation pattern of the coherent source. The stability of the fringe rate shows that the source position is stable to within 700 km on time scales of at least 10 seconds, and apparent position shifts caused by interplanetary scintillations are less than 0.2″. It was found that the observations are most simply interpreted in terms of a small source near the feet of Io-connected magnetic field lines which emits into a thin conical sheet nearly perpendicular to the field lines. (auth)

**15126** RESULTS OF OBSERVATIONS OF JUPITER AT PULKOVO AT 3.95 CM. Soboleva, N. S.; Timofeeva, G. M. (Main Astronomical Observatory, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 685-8(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 872-6(Jul-Aug 1969).

New radio observations of Jupiter at 3.95 cm with a resolution of 1.45′ have indicated that the effective size of the radio-emission region is $35 \pm 3''$ at this wavelength, while the integrated percent of polarization is $(3 \pm \frac{1}{0}\frac{5}{5})\%$. A joint reduction of all the Pulkovo radio observations of Jupiter (at 3.02 cm with a resolution of 1.1′, at 6.5 cm with a resolution of 2.4′) has shown that: (1) the nature of radio emission of radiation belts at these wavelengths is markedly different from their emission in the decimeter region; (2) the brightness temperature of the planet's disc (after the emission of the radiation belts has been taken into account) is substantially higher than that of the infrared (128°K) and millimeter (111°K) spectral regions, and continuously increases with increasing wavelength. The spectrum of the brightness temperature of the planet's disc obtained can be used to define more precisely the model of the planet's atmosphere. (auth)

**15127** SOLAR COSMIC-RAY EFFECTS IN THE LOWER IONOSPHERE OF VENUS. Brown, R. R. (Univ. of California, Berkeley). Planet. Space Sci.; 17: 1923-6(Dec 1969).

The similarity of atomic parameters for the $CO_2$ atmosphere of Venus and that of the Earth is used to calculate the ionization and optical emission rate in the upper atmosphere of Venus resulting from a major solar cosmic-ray event. The possibility of as much as 10 per cent of $N_2$ in the atmospheric composition of Venus does not change these effects appreciably. (auth) (UK)

## Atomic and Molecular Physics

### *Atomic, Electron, Ion, and Molecular Beams and Their Reactions*

*Refer also to abstracts 15214, 15388, and 15398.*

**15128** TRANSACTIONS OF THE CONFERENCE AND SCHOOL ON THE ELEMENTS, TECHNIQUES, AND APPLICATIONS OF SPUTTERING, BRIGHTON, ENGLAND, OCTOBER 20–22, 1969. London; Materials Research Company Ltd. (1969). 190p. 60s. (CONF-691022).

Nine papers are included. A separate abstract was prepared for the one paper in scope entitled, "RF Sputtering of Superconducting Materials." Other papers are included on the following topics: basis of sputtering; physics of sputtering processes; tantalum and tantalum alloy thin film circuits; influence of semiconductor grain boundaries on characteristics of the thin-film transistor; rf sputtering of dielectrics; high-yield sputtering processes; application of sputtering to beam-lead technology; and selection, fabrication, and mounting of sputtering sources. (M.H.R.)

*For an abstract of one paper see: 15214.*

**15129** INELASTIC SCATTERING OF GAMMA RAYS BY K SHELL ELECTRONS. Reddy, D. V. Krishna; Murty, D. S. R. (Osmania Univ., Hyderabad, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 311-14(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210–(Vol.2).

The Compton cross sections of the scattered gammas from a 6.0-Ci $^{137}Cs$ source by different heavy elements of various thick-

nesses at different angles were studied. Some preliminary results are given for 30° scattering on platinum. (M.O.W.)

**15130** FLUX DISTRIBUTION OF SPUTTERED POTASSIUM ATOMS. Politiek, J.; Kistemaker, J. (FOM-Instituut voor atoomen Molecuulfystea, Amsterdam). Radiat. Eff.; 2: 129-31(Jan 1970).

Equations are derived for the sputtering of K atoms by an 8-keV $Ar^+$ ion beam. The effects of the binding energy $E_b$ are considered. A plot of measured collector current vs velocity of the released K atom $v_2$ gives $E_b = 0.71$ eV and $\alpha = 2.05$ ($\alpha$ = exponent in $\Phi(v_1) \propto v_1^{-\alpha}$), differing from the predicted $v^{-3}$ dependence. (D.L.C.)

**15131** METHODS FOR CALCULATING INELASTIC COLLISION CROSS SECTIONS IN LOW-ENERGY COLLISIONS. Bauer, Ernest (Inst. for Defense Analyses, Arlington, Va.). pp 381-429 of Kinetic Processes in Gases and Plasmas. /Hochstim, A. R. (ed.). New York; Academic Press Inc. (1969).

A survey is presented of available approximate methods for calculating inelastic cross sections for encounters between electrons, ions, atoms, and molecules at energies below 100 eV; emphasis focuses on collision processes in air at temperatures below 10,000°K. The aim of the discussion is to supplement the reference works on collision theory by indicating the applicability of the various approximate methods in the domain of present interest. (M.O.W.)

**15132** EXCITATION OF THE $A^2\pi_u$ STATE OF $N_2^+$ BY ELECTRONS. Simpson, F. R.; McConkey, J. W. (Queen's Univ., Belfast). Planet. Space Sci.; 17: 1941-8(Dec 1969).

Absolute values of the emission cross sections for five vibrational bands in the Meinel system of $N_2^+$, $A^2\pi_u$ to $X^2\Sigma_g^+$, excited by electron impact are presented. From these, a value was obtained for the total excitation cross section of the $A^2\pi_u$ state at 100 eV of $26.5 \times 10^{-18}$ cm$^2$. The results are compared with those of other workers and with theory. Collisional transfer of the excitation energy from the levels of the $A^2\pi_u$ state was also observed with a transfer cross section of approximately $10^{-14}$ cm$^2$. (auth) (UK)

## Atomic and Molecular Properties

*Refer also to abstracts 15083, 15084, 15111, 15611, and 15677.*

**15133** INVESTIGATION OF THE HYPERFINE STRUCTURE OF THE $6s6p^3P_1$ STATE OF $^{171}$Yb AND $^{173}$Yb BY OPTICAL DOUBLE RESONANCE. Wandel, G. (Univ., Tuebingen, Ger.). Z. Phys.; 231: 434-49(1970). (In German).

For the odd Yb isotopes $^{171}$Yb and $^{173}$Yb the hyperfine splitting of the $6s6p^3P_1$ state was measured by optical double resonance in zero magnetic field. Taking into account second-order corrections due to the influence of the $6^1P_1$ and $6^3P_{0,2}$ states, the following results for the magnetic splitting constant A and the electric quadrupole interaction constant B were derived: A($^{171}$Yb) = 3958.228 (60) Mcps, A($^{173}$Yb) = −1094.318 (35) Mcps, B($^{173}$Yb) = −825.904 (85) Mcps. The hyperfine structure anomaly of the isotopes $^{171}$Yb and $^{173}$Yb was determined to be $\Delta = -0.352$ (10)%. (auth)

**15134** ELECTRON BINDING ENERGIES IN FREE ATOMS. Lotz, Wolfgang (Institut fuer Plasmaphysik, Garching, Ger.). J. Opt. Soc. Amer.; 60: 206-10(Feb 1970).

Binding energies (ionization energies) of all subshells are given for free atoms up to Z = 108. X-ray data for solids were combined with spectroscopic data and work functions and were smoothed, interpolated, and extrapolated. (auth)

**15135** HANLE EFFECT IN $2^1P$ HELIUM. Fry, Edward Strauss. Ann Arbor, Mich.; Univ. of Michigan (1969). 37p. Thesis.

The oscillator strength for the resonance ($1^1S-2^1P$) transition in atomic helium was determined from a measurement of the lifetime of the $2^1P$ state. This lifetime was obtained using a modified zero-field level-crossing (Hanle) method. The scattering sample was a thermal-velocity beam of $2^1S$ metastable atoms. Resonant 2-micron ($2^1S-2^1P$) radiation is absorbed by the $2^1S$ atoms, which are excited to the $2^1P$ state. This state then decays primarily to the ground $1^1S$ state with the emission of resonance (584 Å) radiation. The lifetime of the $2^1P$ state was determined from measurements of the magnetic field dependence of the 584 Å intensity. This new technique eliminates the problem of constructing a vacuum ultraviolet resonance lamp. The measured lifetime $\tau(2^1P)$ is $(5.69 \pm 0.23) \times 10^{-10}$ sec. The resulting absorption oscillator strength for the resonance transition is $0.270 \pm 0.011$. This oscillator strength agrees with the theoretical value. (Disser. Abstr.)

**15136** RECENT ZEEMAN RESULTS IN Er II. Vander Sluis, K. L.; McNally, J. R. Jr. (Oak Ridge National Lab., Tenn.). J. Opt. Soc. Amer.; 60: 94-7(Jan 1970).

The Zeeman structures at 52,000 Oe of 132 transitions terminating on the 12 lowest levels of the $4f^{12}6s$ configuration of $^{170}$Er II were measured and analyzed. The values of the g factors derived from these data are found to be in excellent agreement with the calculated values of Goldschmidt. (auth)

**15137** NEW RESULTS IN THE STUDY OF GADOLINIUM ARC SPECTRUM. II. NEW EVEN LEVELS AND NEW DEEP ODD LEVELS. Van Kleef, Theodorus Antonius Maria (Univ. of Amsterdam); Slooten, Rob; Blaise, Jean; Camus, Pierre. Compt. Rend., Ser. B; 270: 204-6(19 Jan 1970). (In French).

New lists of emission and absorption wavelengths led to the discovery of ten multiplets of the $4f^7\ 5d^2\ 6s$ configuration. The multiplet $4f^8\ 6s^2\ ^7F$ and 135 new levels were found. (France)

**15138** SECOND BOUND STATE FOR THE HYDROGEN NEGATIVE ION. Drake, G. W. F. (Univ. of Windsor, Ont.). Phys. Rev. Lett.; 24: 126-7(26 Jan 1970).

It is frequently stated that the $1s^2\ ^1S$ state is the only bound state of $H^-$, although Holøien estimated that the $2p^2\ ^3P$ state may also be bound. It is shown by a variational calculation that the $2p^2\ ^3P$ state is definitely bound below the n = 2 threshold of hydrogen. The best eigenvalue obtained is −0.125350 a.u. (auth)

**15139** DETERMINATION OF AN ISOTOPE SHIFT IN THE RATIO OF ATOMIC $g_J$ VALUES OF HYDROGEN AND DEUTERIUM. Hughes, William M.; Robinson, H. G. (Duke Univ., Durham, N. C.). Phys. Rev. Lett., 23: 1209-12(Nov. 24, 1969).

The ratio $g_J(H)/g_J(D)$ in the electronic ground state has been determined using optical pumping of Rb and spin-exchange detection of H and D atomic Zeeman resonances. The result is $g_J(H)/g_J(D) = 1 + (7.2 \pm 3.0) \times 10^{-9}$. The error includes an estimate of possible systematic effects. (auth)

**15140** ELECTRON g FACTOR IN HYDROGENIC ATOMS. Grotch, H. (Pennsylvania State Univ., University Park). Phys. Rev. Lett.; 24: 39-42(12 Jan 1970).

The electron g factor is calculated to a high degree of accuracy for the ground state of hydrogenic atoms. In addition to binding corrections of order $(Z\alpha)^2$, $(Z\alpha)^2 m/M$, and $(Z\alpha)^2(m/M)^2$, radiative level shifts of order $\alpha(Z\alpha)^2$ and $\alpha(Z\alpha)^2 m/M$ are obtained. These level shifts differ from those previously given in the literature. The origin of the discrepancies is discussed in some detail. (auth)

**15141** REVISED $4p^5\ ^2P^0_{\frac{1}{2},\frac{3}{2}}$ SPLITTING OF Y V. Reader, Joseph; Epstein, Gabriel L. (National Bureau of Standards, Washington, D. C.). J. Opt. Soc. Amer.; 60: 140(Jan 1970).

A spectrogram of Y was obtained in which two very strong lines near 600 Å stand out clearly from the rest of the spectrum. From a consideration of isoelectronic regularities, these lines were identified as the two Y V resonance lines, $4s^24p^5\ ^2P^0_{\frac{1}{2},\frac{3}{2}} - 4s4p^6S_{\frac{1}{2}}$. A value of 12459.9 ± 3.0 cm$^{-1}$ was found for the $^2P$ splitting. (A.G.W.)

**15142** MEAN LIVES AND RELATIVE INITIAL-STATE POPULATIONS OF SOME STATES IN He II USING BEAM-FOIL EXCITATION. Dotchin, L. W.; Pegg, D. J.; Chupp, E. L. (Univ. of New Hampshire, Durham). Phys. Lett.; 31A: 85-6(26 Jan 1970).

The mean lives of the 3s and 3d states of $He^+$ were measured to be (9.5 ± 0.8) nsec and (0.93 ± 0.06) nsec, respectively. The relative initial population of these states was studied as a function of energy. (auth)

**15143** STARK SHIFTS WITHIN THE $(1s2s)^3S_1$ STATE OF He. Ramsey, A. T.; Petrasso, R. (Brandeis Univ., Waltham, Mass.). Phys. Rev. Lett.; 23: 1478-80(29 Dec 1969).

The relative Stark shift between the $m_J = \pm 1$ and the $m_J = 0$ Zeeman sublevels of the $2^3S_1$ metastable state in helium was measured. This shift should be zero in the L−S coupling limit. The shift is $(1.27 \pm .04) \times 10^{-6}$ Hz/(V/cm)$^2$, and decreases the normal magnetic field splitting between the $m_J = +1$ and the $m_J = 0$ sublevels. (auth)

## Positronium, Muonium, and Mesic Atoms and Molecules

*Refer also to abstract 15410.*

**15144** TEMPERATURE DEPENDENCE OF THE POSITRON LIFETIME IN $H_2O$ AND $D_2O$. Petersen, K.; Eldrup, M.; Trumpy, G. (Technical Univ., Lyngby, Denmark). Phys. Lett.; 31A: 109-10(9 Feb 1970).

It was found that the lifetime $\tau_2$ and the intensity $I_2$ of triplet positronium in light and heavy water show a sudden transition at the respective melting points for the two substances. (auth)

**15145** DIRECT OBSERVATION OF THE HYPERFINE STRUCTURE AND DEPOLARIZATION OF NEGATIVE MUONS IN THE

MUONIC ATOMS WITH NONZERO NUCLEAR SPIN. Babaev, A. I.; Evseev, V. S.; Myasishcheva, G. G.; Obukhov, Yu. V.; Roganov, V. S.; Chernogorova, V. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 10: 964-72(Nov 1969). (In Russian).

Residual polarization of negative muons is measured by means of the spin procession in the weak transverse magnetic field, for muonic atoms with nuclei of nonzero spin, in targets LiH, Be, $B_4C$, $N_2$, and P. For the mesoatoms in Li and $N_2$ the precession is observed on the frequency of the highest state of the hyperfine structure; for the Be mesoatoms, it is on the frequency of the lowest state. The asymmetry coefficients for the $F = I + 1/2$ state of the hyperfine doublets in LiH, Be, and $N_2$ are $0.0188 \pm 0.0015$, $0.0192 \pm 0.001$, and $0.0134 \pm 0.0017$, respectively. For B and P the residual polarization is near zero at such frequencies. The values of the residual polarization indicate the absence in Li and N, and the presence in B and P, of fast transitions between the hyperfine structure levels in these mesoatoms. The values of the asymmetry coefficients are explained on the basis of the cascade theory of the depolarization with consideration of the final state of the electronic shell in the mesoatom. (auth)

## Collision Phenomena

**15146** (LA-4314) FLUORESCENCE EFFICIENCIES OF NITROGEN EXCITED BY 1- TO 5-MeV POSITIVE IONS. Dunn, Jerry L.; Holland, Redus F. (Los Alamos Scientific Lab., N. Mex.). Nov 1969. Contract W-7405-eng-36. 11p. Dep. CFSTI.

Fluorescence efficiencies for excitation of nitrogen by 1- to 5-MeV positive ions have been measured at pressures of 2 to 19 torr. Typically, a pressure of 3.6 torr was necessary to stop a beam of 4-MeV $Ne^+$ ions in the 150-cm-long collision chamber. Power output in the 3914-Å (0,0) band of the $N_2^+$ first negative system was measured with an interference-filter photometer, and efficiencies for production of this band at lower pressure were calculated from the collisional deactivation rate. For $Ne^+$, $O^+$, $N^+$, $N_2^+$, and $O_2^+$ ions with various intial velocities between 3.1 and $8.3 \times 10^8$ cm/sec, the "low-pressure" efficiencies so determined were in the range 0.4 to 0.6%. For 2.0 and $3.4 \times 10^8$ cm/sec $Kr^+$ ions, efficiencies of 0.27 and 0.35% were obtained. Protons at $1.3 \times 10^9$ cm/sec excited the 3914-Å band with an efficiency of 0.67%. Spectra of the nitrogen emission in the 3400- to 7800-Å range were recorded. $N_2^+$ first negative bands and $N_2$ first positive and second positive bands were prominent in the spectra. Nearly all the first negative emission originated in the $v' = 0$ upper vibrational state. Most of the second positive emission was in the $v' = 0$ to 2 band sequences. Spectral intensities were corrected for effects of collisional quenching, to obtain low-pressure relative efficiencies. Efficiencies for nine second positive bands were determined relative to the 3914-Å efficiencies for excitation by $N^+$, $Ne^+$, $N_2^+$, and $Kr^+$ ions with energies of 4 to 5 MeV. These efficiencies and the relative emission probabilities were used to derive total efficiencies for the second positive $v' = 0$ to 2 sequences, which are about 1.5 times the 3914-Å efficiencies. Efficiencies relative to the 5228-Å (0,3) $N_2^+$ first negative band were determined for 10 first positive bands of the $v' = 2$ to 7 sequences excited by 4.75-MeV $Ne^+$ in $N_2$ at 3.8 torr. After correction for collisional deactivation, the first positive (2,0) and (3,1) band efficiencies, for example, were about 25 times the 5228-Å efficiency, and thus about one-fourth the efficiency of 0.52% obtained for excitation of the 3914-Å band by 4.75-MeV $Ne^+$. After corrections for collision quenching, the spectral distribution of nitrogen fluorescence excited by ions is similar to that in spectra obtained by Hartman for excitation of air by 850-eV electrons. Ratios of efficiencies of the $N_2$ first positive bands to 3914-Å efficiencies are not very different from ratios obtained by Mitchell for excitation of $N_2$ by kilovolt x rays. (auth)

**15147** (NP-18130) ABSOLUTE MEASUREMENTS OF TOTAL CROSS SECTIONS FOR CHARGE EXCHANGE AND ELECTRON LOSS FOR $H_1^+$, $H_2^+$, $H_3^+$ ION INTERACTIONS WITH A WATER VAPOR TARGET. Molina, Daniele (Toulouse Univ. (France). Faculte des Sciences). 1970. 121p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis.

In order to determine the best operating conditions for each type of ion, the behavior of the ion beam was studied for different hydrogen pressures in the source, different source powers and different containment magnetic fields. Then, the mass spectra of the ions coming from the duoplasmatron were studied for hydrogen and other gases such as deuterium, helium, neon, and argon. For detection, a calorimetric detector and a classical electron multiplier were used but the secondary emission coefficients of the cathode had to be determined for each type of ion and neutron studied. $H_1^+$, $H_2^+$, $H_3^+$ ion beams collided with a water vapor target at energies ranging between 1 and 60 keV and their charge-exchange and electron-loss total cross sections were measured. (France)

**15148** (ORNL-TM-2618) ELECTRON IMPACT EXCITATION AND IONIZATION STUDIES OF THE RARE GASES. Grissom, J. T.; Compton, R. N.; Garrett, W. R. (Oak Ridge National Lab., Tenn.). Mar 1970. Contract W-7405-eng-26. 163p. Dep. CFSTI.

Thesis. Submitted by J. T. Grissom to Univ. of Tennessee, Knoxville.

The trapped electron technique was used in conjunction with the retarding potential difference technique to measure the electron impact excitation spectra of He, Ne, and Ar from the energy threshold of the first excited state up to approximately 80 eV with an energy resolution of 0.1 eV to 0.3 eV. Below the ionization threshold the excitation spectra exhibit structure corresponding to the usual singlet-singlet and singlet-triplet transitions. In the slow-electron continuum region above the ionization potential the spectra were found to have structure in the energy regions corresponding to p subshell double-electron excitation and s subshell single-electron excitation. In addition, at least some and possibly many of the spectral features in these energy regions may be due to interference resonances resulting from the formation of negative ion compound states in the electron scattering interaction. Previously reported negative ion resonances are observed in He, and conclusive evidence of new negative ion states is presented for Ne. Unambiguous interpretation of the observed structure in the analogous energy region of the Ar spectrum is complicated by the presence of many autoionizing levels. The general behavior of the slow-electron continuum appears to warrant additional consideration from the result of these studies. The cross section for producing slow electrons in direct ionization was measured for several incident electron energies above the first ionization potential for He, Ne, and Ar. New structure in the ionization cross section of He at 57.21 eV and 58.31 eV corresponding to the previously observed negative ion states $He^-(2s^22p)\ ^2P$ and $(2s2p^2)\ ^2D$, respectively, was observed. The ionization cross sections of He, Ne, Ar, Kr, and Xe were measured from threshold to 150 eV. The results are compared to previous measurements. (auth)

**15149** (UCRL-50174(Sect.3)) COMPILATION OF X-RAY CROSS SECTIONS. SECTION III. McMaster, W. H.; Del Grande, N. Kerr; Mallett, J. H.; Hubbell, J. H. (California Univ., Livermore, Lawrence Radiation Lab.). Aug 1969. 194p. Dep. CFSTI.

This section contains graphs and tables of x-ray cross sections used to obtain the cross section tables of Section II (cross sections in the range of 1 keV to 1 MeV). (auth)

**15150** SINGLE-ELECTRON CAPTURE BY MULTIPLY CHARGED CARBON IONS AT ENERGIES BELOW 40 keV. Zwally, H. Jay. College Park, Md.; Univ. of Maryland (1969). 173p.

Thesis.

Total cross sections for single-electron capture by $C^{4+}$ from the target gases of He, Ne, and Ar were measured at laboratory energies below 40 keV. The relative velocities of collision were in the "near adiabatic" range of 1 to $8 \times 10^7$ cm/sec. Cross sections were also measured for $C^{2+}$ on He, Ne, and Ar and $Kr^{2+}$ on He. The experimental method was to pass an ion beam through a thin gas target under single-collision conditions and to separate and measure the fast collision products according to their charge state. The results are interpreted in terms of the pseudocrossing of the adiabatic potential-energy curves for the initial and the final states. A comparison is made with a cross-section function, $\sigma^{LZ}$, derived from the limited Landau-Zener theory using an empirical value of the interaction matrix element based on previous theoretical and experimental results. Possible contributions to the cross sections caused by transitions that occur away from the pseudocrossing region as described by the numerical solution of the two-state, semiclassical approximation by Bates, Johnson, and Stewart are also considered. The measured cross sections for $C^{4+} + He$, $C^{4+} + Ne$, and $C^{2+} + Ne$ increase toward a possible "second maximum" at much higher velocities than those at which the $\sigma^{LZ}$ function is a maximum; the increase occurs at successively higher velocities for processes with pseudocrossings at successively larger values of the internuclear separation. These characteristics are consistent with the BJS calculated results, which give a second maximum for the process $Mg^{2+} + H$ that also has a distant crossing point. Electron capture with an Auger-type ionization of the target is energetically possible for $C^{4+} + Ne$ and $C^{4+} + Ar$ and is considered as an explanation of the large and slowly varying cross section that is measured for $C^{4+} + Ar$. (Disser. Abstr.)

**15151** DISSOCIATIVE CHARGE EXCHANGE OF $He^+$ AND $Ne^+$ IONS WITH THE MOLECULES $N_2$, $O_2$, AND $CO_2$ AT COLLISION ENERGIES OF 3 TO 200 eV. Schlumbohm, H. (Univ., Hamburg). Z. Naturforsch.; 24a: 1720-4(Nov 1969). (In German).

Cross sections for the dissociative charge-transfer reactions $He^+ + N_2$, $O_2$ and $Ne^+ + N_2$, $O_2$, $CO_2$ were measured over an energy range from 3 to 200 eV and are compared with values given by other authors. The values were determined from measurements of the current of the slow ions formed within a collision chamber. (auth)

**15152** CHARGE EXCHANGE BETWEEN IONS AND ATOMS OF RARE GASES AT COLLISION ENERGIES BELOW 200 eV. Schlumbohm, H. (Univ., Hamburg). Z. Naturforsch.; 24a: 1716-20(Nov 1969). (In German).

Charge-exchange cross sections for the four systems $He^+$, $Ne^+ + Ar$, Kr were measured, applying slow-ion-gathering techniques. The values are several $10^{-16}$ $cm^2$ and are almost constant between 20 and 200 eV collision energy. The comparison with previously published data for charge exchange into optically excited higher states of the ions shows that these reactions prefer at least 25 to 30% endothermic channels instead of the exothermic one without excitation. Additionally the cross section of the endothermic process $Ar^+ + Ne$ was measured. Above a threshold energy of 17 eV it shows a strong increase and a constant value of $7 \times 10^{-17}$ $cm^2$ between 20 and 200 eV. (auth)

**15153** ELECTRON-IMPACT IONIZATION CROSS-SECTIONS FOR ATOMS UP TO Z = 108. Lotz, Wolfgang (Institut fuer Plasmaphysik, Garching, Ger.). Z. Phys.; 232: 101-7(1970).

Electron-impact ionization cross sections for single ionization from the ground state of free atoms up to Z = 108 are given for energies of the impact electron between threshold and 1 keV. The probable error is estimated to be approximately +40, −30%, but near threshold the error is larger and no fine structures are accounted for. (auth)

**15154** RESONANCE IN THE ELASTIC SCATTERING WITH EXCHANGE OF SLOW ELECTRONS BY HELIUM ATOMS. A CALCULATION OF THE JOST FUNCTION. Itikawa, Yukikazu; Ohmura, Takashi; Takayanagi, Kazuo (Tokyo Univ. Nihon Univ., Tokyo). Progr. Theor. Phys. (Kyoto); 42: 993-1002(Nov 1969).

Herzenberg and Lau recently found the appearance of a resonance in the low-energy electron–helium scattering when they modified the exchange interaction by multiplying a factor $(1 + \Delta)$ with $\Delta \neq 0$. In order to see the situation under the unmodified interaction ($\Delta = 0$) clearly, the Jost function for the same scattering problem was calculated. It turns out that the Jost function does not change smoothly as $\Delta$ goes to zero. Hence the extrapolation to the case $\Delta = 0$ is impossible. For the unmodified interaction ($\Delta = 0$), with the simple Hartree–Fock-type target function used, the Jost function always vanishes and thus the presence of the resonance in this problem can be neither proved nor disproved. (auth)

**15155** ELECTRONIC–VIBRATIONAL STATES OF IONS FORMED BY ELECTRON IMPACT. Ovchinnikov, A. A. Opt. Spectrosc. (USSR) (Engl. Transl.); 26: 383-6(May 1969).

Translated from Opt. Spektrosk.; 26: 696-703(May 1969).

The electronic-vibrational states of molecular ions formed by the collision of fast electrons with molecules are studied. The vibrational energy distribution in the molecular ion is investigated. A distribution function is set up on the assumption that the vibration frequencies of the molecule and the ion are the same and that the probabilities of formation of the vibrational states are determined by Franck–Condon factors. The average energy and the dispersion of the distribution function are obtained in explicit form. (auth)

**15156** RESONANCES IN ELECTRON IMPACT EXCITATION OF $H_2$ BY A TRAPPED ELECTRON METHOD. Hall, R. I.; Mazeau, J.; Reinhardt, J. (Faculte des Sciences, Paris). Phys. Lett.; 31A: 145-6(9 Feb 1970).

Electron impact excitation of $H_2$ in the 11- to 13.5-eV energy range was observed from threshold to about 0.3 eV above threshold using a trapped electron method. At above 0.2 eV above threshold, new structure is seen to be superimposed on the threshold spectrum. This is interpreted as being due to resonances in the excitation cross sections of the $B^1\Sigma_u^+$ and $c^3\Pi_u$ states of $H_2$. (auth)

**15157** INFLUENCE OF IONIC EXCITATION IN HEAVY-ION CHARGE-CHANGING CROSS SECTIONS. Ryding, G.; Betz, H. D.; Wittkower, A. (High Voltage Engineering Corp., Burlington, Mass.). Phys. Rev. Lett.; 24: 123-5(26 Jan 1970).

The influence of ionic excitation on heavy-ion charge-changing collisions was studied by measuring cross sections for electron capture and loss as a function of target-gas density. The results show a decreased probability for electron capture rather than the increased probability for electron loss predicted by Bohr and Lindhard. (auth)

**15158** PROTON CHARGE TRANSFER WITH FORMATION OF HIGHLY EXCITED HYDROGEN ATOMS. Le Doucen, R.; Guidini, J. (EURATOM-CEA, Fontenay-aux-Roses, France). Rev. Phys. Appl.; 4: 405-8(Sep 1969). (In French).

A study was made of the formation of highly excited hydrogen atoms, having principal quantum numbers $n \geq 9$, by charge exchange of 20 to 150-keV protons in the gases $H_2$, Ar, and He. The relative yield of highly excited atoms was determined by ionizing them in a strong electric field. A maximum for the yield of these atoms was found at the same order of the energy in the cases of $H_2$ and Ar. (auth)

**15159** CHARGE-TRANSFER REACTIONS OF SOME NEGATIVE IONS WITH $O_2$ AND THE ELECTRON AFFINITY OF $O_2$. Vogt, D.; Hauffe, B.; Neuert, H. (Univ., Hamburg). Z. Phys.; 232: 439-42(1970). (In German).

Investigations of the energy dependence of the cross section of charge-transfer reactions with negative ions yield information on the relative values of the electron affinities of the colliding particles. It is shown that $H^- + O_2$ and $SO^- + O_2$ are exothermic and that $ND_2^- + O_2$ is an endothermic reaction. With EA(H) = 0.776 eV, EA(SO) = 1.05 eV and $EA(ND_2) \approx 1.2$ eV it is found that 1.05 eV < $EA(O_2) < \approx 1.2$ eV. (auth)

**15160** ANGULAR DISTRIBUTIONS OF ELECTRONS SCATTERED ELASTICALLY AND INELASTICALLY (ENERGY LOSS 6.7 eV) AT FREE MERCURY ATOMS. Gronemeier, K.-H. (Johannes Gutenberg-Univ., Mainz). Z. Phys.; 232: 483-8(1970). (In German).

The angular dependence of electrons scattered elastically and inelastically at free mercury atoms was measured for electron energies between 20 and 300 eV (angular range from 20 to 155°). (auth)

**15161** THE EMISSION OF NEGATIVELY CHARGED SECONDARY MOLECULAR IONS FROM CONTINUOUSLY REGENERATED TARGET SURFACES. Mokler, P. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Phys.; 232: 452-61(1970). (In German).

The processes that govern the emission of molecular ions from continuously regenerated surfaces were studied. A rotating iron target was bombarded by noble gas ions in the energy range from 17 to 30 keV. The secondary ion yield was measured as a function of primary current density, mass and energy of the primary ions, gas pressure and the rotation frequency of the target. (auth)

**15162** AUTO-IONIZING ELECTRONS FROM ARGON WITH ENERGIES 150 TO 210 eV AS PRODUCED BY $H_2^+$ AND $H_2$ IMPACTS. Volz, Donald James. Lincoln, Neb.; Univ. of Nebraska (1969). 138p.

Thesis.

Electrons in the range 150 to 210 eV as produced by 125- to 300-keV $H^+$ and 300-keV $H_2^+$ impacts on argon are energy-analyzed by a parallel-plate analyzer and detected with a 14-stage electron multiplier. The experimental arrangement is such that the count rate of the electrons detected at various angles can be plotted as a function of the electron energy on a X–Y recorder. The auto-ionizing transitions appear as sharp peaks superimposed on a continuous background. The peak heights above the continuum and the energy values of these peaks permit the identification of the five levels $2p^5(^2P_{3/2})$, $2p^53P^5$ $(^3P_{0,1,2})$. The branching ratios, natural widths, and absolute energies of these levels are determined. The natural widths varied from .24 ± .05 eV to .47 ± .07 eV for the identified levels. The intensities of the transitions are determined absolutely by comparison with other data and the excitation cross sections of the $2p^5(^2P_{3/2})$ levels are measured as a function of the incident proton energy. The excitation cross section per electron of these two levels is the same within experimental error and varied approximately linearly from $(1. \pm .27) \times 10^{-23}$ $m^2$ for 125-keV $H^+$ to $(2.8 \pm .27) \times 10^{-23}$ $m^2$ for 300-keV $H^+$. The excitation of the $2p^53p^5(^3P_{0,1,2})$ levels by 300-keV $H_2^+$ is found to be approximately 1.5 times larger than excitation by $H^+$ at the same velocity, whereas excitation of the $2p^5(^2P_{3/2})$ levels is approximately the same. The angular dependence of the auto-ionizing electrons is examined and found to be nearly isotropic. (Disser. Abstr.)

**15163** MULTIPLE EXCITATION OF NEON BY PHOTON AND ELECTRON IMPACT. Krause, M. O.; Stevie, F. A.; Lewis, L. J.; Carlson, T. A.; Moddeman, W. E. (Oak Ridge National Lab., Tenn.). Phys. Lett.; 31A: 81-2(26 Jan 1970).

It is shown that the shakeoff theory holds for both photon and electron excitation. Relative intensities are given for diagram and satellite lines of the K-Auger spectrum of neon. (auth)

**15164** COLLISION-INDUCED DISSOCIATION OF $(HeH)^+$ RESULTING IN $He^+$ AND H. Schopman, J.; Los, J. (FOM-Instituut voor Atoom- en Molecuulfysica, Amsterdam). Phys. Lett.; 31A: 79-80(26 Jan 1970).

The momentum distribution of the $He^+$ fragments from the collision-induced electronic excitation of the $(HeH)^+$ molecular ion has an a-symmetry between the forward and backward direction. Moreover two dissociation mechanisms are involved. (auth)

**15165** COLLISION SPECTROSCOPY OF THE SYSTEM $Li_2^+$. Aberth, W.; Bernardini, O.; Coffey, D. Jr.; Lorentz, D. C.; Olson, R. E. (Stanford Research Inst., Menlo Park, Calif.). Phys. Rev. Lett.; 24: 345-9(23 Feb 1970).

Differential scattering measurements are reported for the elastic reaction $Li^+ + Li \rightarrow Li^+ + Li$ at 25 to 150 eV (cms) and the inelastic reaction $Li^+ + Li(2s^2S) \rightarrow Li^+ + Li(2p^2P)$ at 25, 50, and 100 eV. The elastic cross sections show a rainbow peak at $E\theta_R \simeq 80$ eV deg, curve-crossing perturbations, and possibly electron-transfer oscillations. The inelastic cross sections have an oscillatory structure with a threshold at $E\theta_x \simeq 70$ eV deg. These observations are interpreted in terms of the diabatic electronic states of $Li_2^+$. (auth)

**15166** THE CROSS SECTION FOR THE $J = 0 \rightarrow 2$ ROTATIONAL EXCITATION OF HYDROGEN BY SLOW ELECTRONS. Crompton, R. W.; Gibson, D. K.; McIntosh, A. I. (Australian National Univ., Canberra). Aust. J. Phys.; 22: 715-31(Dec 1969).

The results of electron drift and diffusion measurements in parahydrogen were analyzed to determine the cross sections for momentum transfer and for rotational and vibrational excitation. The limited number of possible excitation processes in parahydrogen and the wide separation of the thresholds for these processes make it possible to determine uniquely the $J = 0 \rightarrow 2$ rotational cross section from threshold to 0.3 eV. In addition, the momentum transfer cross section was determined for energies less than 2 eV and it is shown that, near threshold, a vibrational cross section compatible with the data must lie within relatively narrow limits. The problems of uniqueness and accuracy inherent in the swarm method of cross section analysis are discussed. The present results are compared with other recent theoretical and experimental determinations; the agreement with the most recent calculations of Henry and Lane is excellent. (Australia)

**15167** VALUE AND LIMITATIONS OF QUASI-FREE ELECTRON SCATTERING EXPERIMENTS ON ATOMS. Amaldi, U. Jr.; Ciofi Degli Atti, C. (Istituto Superiore di Sanita, Rome). Nuovo Cim.; 66A: 129-38(1 Mar 1970).

The quasi-free (e,2e) experiments on atoms and molecules recently proposed have proved to be technically feasible and their value and limitations are discussed here. The scope of this paper is to show how this line of research will provide new and detailed information on electron wave functions in atoms and eventually also in molecules. It also deals with an important point overlooked in previous papers suggesting these experiments—the way in which the "unavoidable" accidental rate limits the number of states that can be studied. This is not an experimental problem but lies in the very nature of the reaction itself. (auth)

**15168** MODEL FOR BEAM–FOIL EXCITATION OF $He^+$. Yager, Robert Eugene. Houston, Tex.; Rice Univ. (1969). 111p. Thesis.

The distribution of excited states in a high-energy $He^+$ beam passing through a thin carbon foil was studied both experimentally and theoretically. The experiments were designed to determine the relative populations of the orbital angular momentum states in the $n = 5$ level and the total population of the $n = 5$ level in $He^+$ as a function of incident ion energy. Predictions of these populations were made using a free atom model of the carbon foil. Direct excitation of $He^+$ from the ground state, deexcitation of excited states of $He^+$, transitions among states in the $n = 5$ level, and capture of an electron from carbon by $He^{++}$ into an excited state of $He^+$ were considered and cross sections were calculated in the Born approximation for these processes. The rate equations were evaluated to obtain the predicted populations for comparison with experiments. (Disser. Abstr.)

**15169** MEASUREMENT OF THE CROSS SECTIONS $\sigma_{01}$ AND $\sigma_{01}^*$ OF HELIUM ATOMS AT ENERGIES 10 TO 50 keV IN HYDROGEN AND NEON. Bastien, Francois; Depuydt, Eliane; Sinturel, Annie (Faculte des Sciences, Paris). Compt. Rend., Ser. B; 269: 459-62(15 Sep 1969). (In French).

From a study of the decrease in the number of atoms of a neutral helium beam containing a fraction f of metastable atoms in the course of a charge exchange reaction, the values of f, $\sigma_{01}$, and $\sigma_{01}^*$ were obtained. The values of $\sigma_{01}$ and $\sigma_{01}^*$ were normalized by extrapolation of the values obtained for $E > 60$ keV by Gilbody. (tr-auth)

## *Atomic Theory*

*Refer also to abstract 15662.*

**15170** (CEA-R-3929) RELATIVISTIC HARTREE–FOCK CALCULATIONS WITH EXCHANGE. Desclaux, Jean-Paul (Commissariat a l'Energie Atomique, Limeil-Brevannes (France). Centre d'Etudes). Jan 1970. 32p. (In French). Dep. CFSTI (U. S. Sales Only).

A relativistic Hartree–Fock calculation of atomic wave functions is carried out. The Hamiltonian consists of the sum of the Dirac Hamiltonians and the interelectronic Coulomb repulsion terms. The first term of the Breit operator is used as the relativistic interelectronic interaction term and is treated as a first-order perturbation. A numerical program that computes the radial functions, energy eigenvalues, and total energy for any atom, the wave function of which is a single Slater determinant, is described. Numerical results for the ground states of Be, Ne, Xe, Hg, and Rn atoms and the $^2D$ state of copper are also presented. (auth) (France)

**15171** DETERMINATION OF CORRELATION ENERGIES. Kamuntavichyus, G.; Shugurov, V. (Vilnyus State Univ.). Liet. Fiz. Rinkinys, Liet. TSR Mokslu Akad., Liet. TSR Aukst. Mokyklos; 9: 287-97(1969). (In Russian).

Green's functions are used in perturbation theory to calculate the correlation energy of some light atoms. Some easily applied formulas are given. (auth)

**15172** COMMENT ON A PERTURBATION TREATMENT OF THE GROUND STATE OF TWO-ELECTRON ATOMS USING THE COORDINATES $r_<$ AND $r_>$. White, Ronald J. (Bell Telephone Labs., Inc., Murray Hill, N. J.); Ramaker, D. E.; Schrader, David M. Int. J. Quant. Chem.; 4: 1-3(Jan 1970).

A perturbation variation treatment of two-electron atoms using $\exp(-\alpha r_< - \beta r_>)$ as the zeroth-order wave function is presented. The parameters $\alpha$ and $\beta$ are variationally determined and the results are compared with the "physical" choice $\alpha = Z$, $\beta = Z - 1$, and with $Z^{-1}$ theory. The energy is given through fifth order in the perturbation. (auth)

**15173** THE REFORMULATIONS OF THE KLEIN–GORDON AND DIRAC EQUATIONS FOR THE HYDROGEN ATOM TO ALGEBRAIC FORMS. Lanik, J. (Inst. of Physics, Bratislava). Czech. J. Phys.; 19: 1540-8(1969).

The Klein–Gordon and Dirac equations of the H atom are rewritten to algebraic forms within the framework of the Lie algebras of the $SO(2,1) \oplus SO(3)$ and $SO(2,1) \oplus SU(2)$ groups, respectively. The algebraic equations obtained are solved purely within the framework of group theory. In such a way, the exact and right formulas of the discrete and continuous energy spectra of the relativistic H atom are obtained. (auth)

# Cosmic Radiation

*Refer also to abstracts 14252, 15064, 15118, 15442, 15443, 15449, 15454–15456, 15468, and 15603.*

**15174** NATURE OF PRIMARY COSMIC RADIATION. Powell, C. F. Sci. World; 13: 5-13(1969).

A historical review is given of the discovery of cosmic radiation. In a decisive experiment in 1912, Hess, during a manned balloon flight to an altitude of about 5 km observed the variation of the ionization current throughout the flight. He found that at the maximum altitude reached the current was 4 times greater than at sea level, and he concluded that a very penetrating radiation is entering the atmosphere from out of space. These results were confirmed during the next 7 yr by higher manned balloon flights. Later, Millikan showed that the observed attenuation of cosmic radiation in the atmosphere could not be accounted for in terms of a primary stream of high-energy quanta with a single quantum energy. In 1929, by a radical, new technique, it was shown at least a large part of the cosmic-ray flux in the atmosphere must be in the form of penetrating material particles and could not be made up of $\gamma$ rays alone. The discovery of the latitude effect and the east–west effect showed that a large proportion of the primary radiation must be positively charged, and so influenced in its approach to the earth by the magnetic field. The study of cosmic radiation, which provided a weak stream of particles many orders of magnitude more energetic than any generated artificially in the laboratory, played a leading role in the advancement of the physics of elementary particles and led to such important results as the discovery of the positive electron and air-production of the muons or heavy electrons, and of the pions, kaons, and hyperons. (BBB)

**15175** ORIGIN OF COSMIC RAYS AND HIGH ENERGY COSMIC RAYS. Berezinskii, V. S.; Zatsepin, G. T. (Lebedev

Inst. of Physics, Moscow). Yadern. Fiz.; 10: 1228-37(1969). (In Russian).

Theories of origin of cosmic rays are discussed in which the spectrum of the primary cosmic rays has no cutoff at $E \sim 10^{19}$ to $10^{20}$ eV. The theory of cosmic rays as relics of a Metagalaxy is discussed in particular. (auth)

**15176** HOT UNIVERSE MODEL AND THE DIRAC MONOPOLE PROBLEM. Domogatskii, G. V.; Zheleznykh, I. M. (Lebedev Inst. of Physics, Moscow). Yadern. Fiz.; 10: 1238-42(1969). (In Russian).

The possible concentration of the relict magnetic charges (monopoles) is calculated in the framework of the Hot Universe model. The restrictions on the value of the monopole–antimonopole annihilation cross section and also on the mass of the monopole can be obtained by comparing the calculated concentration of the monopoles in cosmic rays with the experimental data. (auth)

**15177** THE EFFECTS OF CHERENKOV LIGHT PULSES ON A STELLAR INTENSITY INTERFEROMETER. Brown, R. Hanbury; Davis, J.; Allen, L. R. Mon. Notic. Roy. Astron. Soc.; 146: 399-409(1969).

Observations of Cherenkov light pulses due to cosmic rays were made, using the large reflectors of the stellar-intensity interferometer at Narrabri Observatory. The rate of arrival of correlated pulses in the two reflectors was measured as a function of the pulse height, zenith angle, separation, and relative alignment of the two reflectors. The results are used to calculate the unwanted correlation due to Cherenkov light in the interferometer at Narrabri, and it is found to be negligibly small compared with the correlation due to the faintest stars in the programme. It is shown that a more serious limit to the sensitivity of the interferometer is set by the general background light from the night sky, and it is pointed out that this conclusion applies generally to larger and more sensitive instruments. (auth) (UK)

**15178** ELECTRON LATERAL DISTRIBUTION IN EXTENSIVE AIR SHOWERS OF COSMIC RAYS (THEORY). Dupuy, Jean; Cachon, Andre; Capdevielle, Jean-Noel (Observatoire du Pic du Midi, Bagneres-de-Bigorre, France). Compt. Rend., Ser. B; 270: 118-21(5 Jan 1970). (In French).

With the help of a method of simulation of extensive air showers of cosmic rays, the lateral distribution of the photoelectron component was calculated. The effect of all the photoelectron cascades occurring during the shower development was taken into account. These calculations were made for all primary cosmic particle energies between $10^{13}$ and $10^{21}$ eV and for different parameter combinations. The inelasticity effect seems to be preponderant. (FRANCE)

## Direct Energy Conversion

**15179** (N-70-12367) A DESIGN STUDY FOR A MAGNETOHYDRODYNAMIC POWER SYSTEM FOR A NUCLEAR ELECTRIC PROPELLED UNMANNED SPACECRAFT. Quarterly Progress Report, May 26–September 25, 1969. (General Electric Co., Philadelphia, Pa. Missile and Space Div.). Contracts NAS7-100; JPL-952415. 192p. (NASA-CR-106995; GESP-7017). CFSTI. For Jet Propulsion Lab., Pasadena, Calif.

The progress made in the first quarter of a one-year design study of nuclear-electric propelled unmanned spacecraft using a magnetohydrodynamic (MHD) power system is discussed. Included as appendices is the analytical treatment of the MHD system upon which the spacecraft analysis is based. The study guidelines and approach are defined here, and the characteristics of one launch vehicle, the thruster subsystem, and the payload and communications system are presented. The MHD power conversion system is described and methods used to calculate MHD system parameters are discussed. Included are the initial estimation of baseline (300 kWe) system design parameters and a discussion of the arrangement and structural arguments used to select system configuration. The system startup technique is identified, and the nuclear reactor and primary radiator characterization are presented (auth) (STAR)

**15180** INVESTIGATION OF $^3$He PLASMA PARAMETERS FOR APPLICATION TO NUCLEAR MAGNETOHYDRODYNAMIC POWER GENERATION. Cofer, Horace Gorrell. Gainesville, Fla.; Univ. of Florida (1968). 235p.

Thesis.

A new technique for studying electron kinetics in plasmas produced by neutron irradiation was developed in view of the need for experimental information on the kinetics of neutron-induced plasmas and the attractiveness of coupling such a scheme for MHD power generation with a nuclear reactor. This technique was used to perform equilibrium-type measurements. The approach utilized the principle of high-voltage pulse application to the chamber containing the plasma, thereby collecting the electrons and relating the resulting current from the chamber and the respective voltage developed to the electron density present at the time of electron collection. Expressions were developed for relating the current as a function of the geometry of the chamber and for relating the voltage as a function of the RC time constant of the system. A series of measurements were performed on various gas compositions at pressures over the range of one to ten atmospheres. The results of the experiments demonstrated the effectiveness of the experimental method. Values obtained for the recombination coefficient for helium, ($^3He_2^+$), were $3.36 \times 10^{-9}$ cm$^3$/sec, $4.0 \times 10^{-8}$ cm$^3$sec, and $5.45 \times 10^{-8}$ cm$^3$/sec for pressures of one atmosphere, six atmospheres, and ten atmospheres respectively. This approximate direct variation with pressure indicates a mechanism involving a positive ion, electron, and neutral atom. The kinetics of $^3$He plasma were studied, since $^3$He offers the unique property of a high absorption cross section for thermal neutrons which cause a reaction yielding an excess energy of 764 keV. This energy is imparted to the reaction yielding an excess energy of 764 keV. This energy is is imparted to the reaction products in the form of kinetic energy which is absorbed by the gaseous system through collisional and near-collisional events between the charged products and the electrons of the constituents of the gas, producing ionization. Helium offers the most acceptable properties for use as a gas coolant in a nuclear reactor. Therefore, $^4$He seeded with $^3$He represents a prospective medium for a working fluid for a nuclear MHD system. In addition to evaluating possible MHD working fluids as a function of pressure, the pulsed ion chamber diagnostic technique, which was developed in this work, offers a means of studying other relationships involving electron behavior. It is shown that an approach of nuclear seeding coupled with the pulsed ion chamber technique provides an opportunity for a series of interesting and important experiments involving the interactions of radiation with matter. (Diss. Abstr. Int., B)

## Fluid Physics

*Refer also to abstract 15322.*

**15181** FINITE-AMPLITUDE EFFECTS ON MAGNETOHYDRODYNAMIC THERMAL CONVECTION IN A ROTATING LAYER OF A CONDUCTING FLUID. Gupta, A. S.; Rai, Lajpat (Indian Inst. of Tech., Kharagpur, India). J. Math. Anal. Appl.; 29: 123-40 (Jan 1970).

Since it is known from linear stability analysis that a magnetic field and rotation do not always reinforce each other in inhibiting thermal convection, the finite amplitude effects in a conducting layer are studied when both rotation and magnetic field are present. It is shown that subcritical instability is possible when either the magnetic field and rotation act conjointly or separately. (M.H.R.)

**15182** FORCE-FREE MAGNETIC FIELDS IN RESISTIVE MAGNETOHYDROSTATICS. Jette, A. David (Univ. of Calgary, Alberta, Can.). J. Math. Anal. Appl.; 29: 109-22(Jan 1970).

It is proven that, in resistive magnetohydrostatics, the only force-free magnetic fields B which remain force-free in time are those for which $\alpha$ is constant in space and time, where $\alpha$ is defined by $\nabla \times B = \alpha B$. (auth)

**15183** UNSTEADY MAGNETOHYDRODYNAMIC FLOW IN A CIRCULAR PIPE UNDER A TRANSVERSE MAGNETIC FIELD. Gupta, S. C. (Royal Roads Military Coll., Victoria, British Columbia); Singh, Bani. Phys. Fluids; 13: 346-52(Feb 1970).

An exact solution for unsteady magnetohydrodynamic flow in a circular pipe (with a uniform magnetic field parallel to a diameter of the cross section) with insulating walls has been obtained. For comparison, graphs have been plotted for the magnetic field in the magnetohydrodynamic case and for velocity in the hydrodynamic and magnetohydrodynamic cases at different times. (auth)

**15184** STABILITY OF GAS–LIQUID SYSTEM IN A MAGNETIC FIELD. Buti, B. (Indian Inst. of Tech., New Delhi); Kalra, G. L.; Kathuria, S. N. Phys. Fluids; 13: 364-71(Feb 1970).

The interfacial stability of a compressible gas flowing past an incompressible, viscous liquid layer is investigated in the presence of a uniform magnetic field and uniform rotation transverse to the field, both the field and the rotation being in the plane of the interface. When the magnetic field is along the direction of the streaming of the gas, there exists a critical magnetic field $H_c$ in the subsonic case such that for $H > H_c$, the system is stable; in the supersonic case, however, $H_c$ does not occur. The rotation in the previous case tends to stabilize the system whereas in the

latter case it has a destabilizing effect. If the magnetic field is transverse to the streaming velocity, then for supersonic flows the system is always stable provided gravity is acting from gas toward liquid. For subsonic flows, there appears to be a critical rotation $\Omega_c$ such that only for $\Omega > \Omega_c$ is the system stable. However $\Omega_c$ decreases with the magnetic field which once more acts as a stabilizer. (auth)

**15185** THEORY FOR OSCILLATIONS IN MPD ACCELERATORS. Witalis, E. A. (Research Inst. of the Swedish National Defence, Stockholm). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1383-5(Jul 1969).

A theoretical explanation is presented for the rotational arc motion in steadily operated coaxial MPD thrusters with strong axial fields. Basic plasma equations are combined with frozen flow conditions to predict the inductive rotational motion due to Hall effect and expansion. Good agreement with experiments is obtained. (D.L.C.)

**15186** HYDROMAGNETIC VISCOUS FLOW GENERATED BY A DIVERGING ELECTRIC CURRENT. Lundquist, Stig (Institutet foer Hoegspaenningsforskning, Uppsala). Ark. Fys.; 40: 89-95(1969).

In a fluid conductor the presence of an electric current which diverges radially from a point source will give rise to fluid motion. A stationary solution to this problem is given for a viscous, incompressible fluid when the magnetic Reynolds number remains small. This corresponds to total currents below a critical value determined by the viscosity and the resistivity of the fluid. (Sweden)

**15187** AN ACTUATOR-DISK MODEL FOR AZIMUTHALLY NONUNIFORM MPD ARCS. Fay, James A.; Cochran, Robert A. (Massachusetts Inst. of Tech., Cambridge). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1688-92(Sep 1969).

Recent experiments have shown that, under some conditions of operation, the current pattern in an MPD arc is azimuthally nonuniform and rotates with a constant angular velocity, which increases with current and applied magnetic field but decreases with propellant mass flow rate. A model for such a flow is proposed, based on the physical assumption that the current flows in a single column and upon the mathematical assumption that azimuthal averages of mass, momentum, and energy fluxes are time-invariant. The model is thus analogous to the actuator-disk model, which describes the flow induced by a propeller. Additional hypotheses are made concerning flow properties and arc motion, based on a limited experimental and theoretical understanding of magnetically balanced arc columns. A dimensionless correlation of all existing experimental measurements is derived and a criterion for the existence of current spokes is suggested. (auth)

**15188** ELECTRIC ARC STABILIZATION IN CROSSED CONVECTIVE AND MAGNETIC FIELDS. Winograd, Y. Y.; Klein, J. F. (Massachusetts Inst. of Tech., Cambridge). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1699-1703(Sep 1969).

An experimental study of the behavior of an electric arc in crossed convective and magnetic fields was made and the results compared with a theory developed by Cowley for such arcs. The arc, of 7 to 70 A, was held stationary between two parallel rail electrodes, mounted in a small wind tunnel, with nitrogen as the working gas. The velocity in the test section ranged between 0 and 40 m/sec, and the corresponding magnetic field between 0 and 500 gauss. A drag coefficient, based on the measured dimension of the arc transverse to the flow, was found to depend on the free-stream Reynolds number based on the same dimension and to have values between 0.82 and 1.8. The stable configuration for the arc was with the column slanted across the electric-field lines, the cathode spot downstream of the anode spot. The slant of the arc was related to the widening of the column near the downstream electrode. (auth)

## Geophysics (Upper Atmosphere)

*Refer also to abstract 15132.*

**15189** GEOMAGNETIC PULSATIONS. Saito, Takao (Tohoku Univ., Sendai). Space Sci. Rev.; 10: 319-412(Dec 1969).

Observational features and occurrence models of geomagnetic pulsations are extensively reviewed. Topics covered include Pc1 pulsations, Pc2 and -3 pulsations, Pc4 and -5 pulsations, P1 and -2 pulsations, IPDP pulsations, Pi(c) pulsations, miscellaneous pulsations, and geomagnetic pulsations and the Earth's environments from the Sun to the Earth's interior. 270 references. (W.D.M.)

**15190** AURORAL ELECTRONS. Rees, M. H. (Univ. of Colorado, Boulder). Space Sci. Rev.; 10: 413-41(Dec 1969).

Satellite and rocket measurements of auroral electrons (which have been made since Brown's (1966) and Pfister's (1967) papers have appeared) are reviewed, and the salient characteristics of auroral electrons which emerge from all types of measurements are summarized. Effects of the atmosphere on the energy distribution of electron fluxes are discussed. Ionization rates associated with typical fluxes are derived. Observable effects produced in the atmosphere and the fate of auroral electrons are briefly described. 54 references. (auth)

**15191** KINETIC THEORY OF THE BOUNDARY BETWEEN THE SOLAR WIND AND THE MAGNETOSPHERE. LaQuey, Robert Eugene. Houston, Tex.; Rice Univ. (1969). 160p. Thesis.

The microscopic structure of the boundary layer between two such magnetized plasmas is examined in the Vlasov–Maxwell approximation (collisionless kinetic equation with self-consistent fields) with an aim toward determining the macroscopic boundary conditions that are to be associated with such a boundary. The Ferraro–Rosenbluth cold plasma sheath between a beam of charged particles and a magnetic field is reexamined. It is shown that solutions to the full system of differential equations describing the Ferraro–Rosenbluth cold plasma sheath can always be constructed exhibiting the properties: (1) the electrons turn back before the ions, and (2) the sheath is overall charge neutral. The mathematical basis for results to the contrary obtained by Sestero and by Davies is the fact that the problem is underspecified by the usual boundary conditions. Exact stationary solutions to the one-dimensional Vlasov boundary layer problem are constructed. These solutions demonstrate that an equilibrium can be constructed which allows for streaming of the solar wind plasma along the magnetic field. The problem initially posed by Parker concerning the existence of an equilibrium in such a situation is thus resolved. The microscopic instability of these boundary layers is then examined in the electrostatic approximation. An integral equation is derived which describes the propagation of electrostatic fluctuations in the boundary layer. Stability of the boundary layer is then determined by analysis of an approximate dispersion relation that is derived from the integral equation. In this approximation the boundary layer is found to be unstable to the propagation of drift waves and drift-cyclotron waves. These waves are found only in a plasma having spatial gradients and are particularly likely to be generated within a boundary layer. The scattering of particles by the enhanced fluctuations leads to diffusion and an effective viscosity which is computed. The resulting viscosity is adequate to explain the observed magnetospheric convection. The diffusion provides a mechanism for limiting the length of the tail, but the effect proceeds so slowly that the tail could well be several astronomical units in length. Thus, the existence of a tail of great length is compatible with the occurrence of magnetospheric convection driven by viscous interaction with the solar wind. (Diss. Abstr.)

**15192** STRUCTURE OF THE DAYSIDE EQUATORIAL MAGNETOSPHERIC BOUNDARY AS DEDUCED FROM PLASMA FLOW. Warren, Carlos Scott. Houston, Tex.; Rice Univ. (1969). 173p. Thesis.

On January 13 and 14, 1967, during an intense magnetic storm, anisotropic fluxes were detected by the Rice suprathermal ion detector for several hours beginning at approximately 1300 local time. The detector is onboard the geostationary satellite ATS-1 that is located at 6.6 earth radii. For the first hour, the observed ions flowed in a generally sunward direction with very little angular spread. The characteristic energy of the ions was a few eV. At approximately 1400 local time, coincident with a magnetic field reversal at the satellite, the ion flow changed to a generally anti-sunward direction with the energy of the majority of the particles being >50 eV. Until approximately 1510 local time, the energy and flow characteristics of the ions as well as local magnetic field strength and direction varied. Following this, the ion flow pattern returned to the low-energy directed flow similar to that seen before the field reversal. It has been established that the varied magnetic fields and plasma flow observed at the satellite were due to a compression of the magnetospheric boundary to the ATS-1 orbit. During the time of the compression, plasma data were recorded inside the magnetosphere, the magnetosheath, and inside the magnetospheric boundary itself. The data generally support the view that a convective-type interaction exists between the magnetosheath plasma and the magnetospheric plasma. Just inside the boundary region, where the maximum interaction is expected, ion flow characteristics are similar to those in the magnetosheath. Several cases of ion flow relative to the magnetic field direction are examined for periods when the magnetic field lay predominantly in the equatorial plane. The implications of these data for a closed and open magnetosphere are discussed. (Diss. Abstr.)

**15193** SATELLITE OBSERVATIONS OF SOFT PARTICLE FLUXES IN THE AURORAL ZONE. Heikkila, W. J. (Univ. of Texas, Dallas). Nature (London); 225: 369-70(24 Jan 1970).

A preliminary report is presented on measurements of electron and proton precipitation in the auroral zone using a soft-particle spectrometer in the ISIS-1 satellite. Recordings were made at the telemetry station at Tromsö, Norway, in Sept. 1969 during a period of moderate auroral activity, and with the satellite at ~1,000 km. A brief description is given of the spectrometer and its mode of operation. It was found that at these high latitudes the electron flux was highly structured, with quiet periods interrupted by bursts of electrons with energies up to 1 or 2 keV. The proton spectrum showed a maximum count of $3 \times 10^3$ at 2,000 eV. The electrons and protons carried equal amounts of energy (~0.1 erg $cm^{-2}$ $sr^{-1}$ $s^{-1}$). It was difficult to distinguish any spin modulation at high latitudes, but the general impression was that of a broad angular distribution. These results are compared with those at lower latitudes. In an example of electron precipitation in the impulsive morning region, a pronounced peak appeared at 1 keV, shifting quickly up to 5 keV and then slowly back to 2 keV. The energy flux reached 3 erg $cm^{-2}$ $sr^{-1}$ $s^{-1}$. Results confirmed the precipitation patterns inferred from many different types of ground-based observations. The discrete precipitation structures found at higher latitudes are associated with bright localized auroral forms and other rapidly varying phenomena. The most obvious feature of the observed spectra is a narrow peak in the 100- to 10,000-eV range, with the highest energy fluxes carried generally in the upper part of this range. This narrow peak suggests an electrostatic field as the acceleration mechanism. The impulsive precipitation at higher latitudes is undoubtedly due to processes occurring in the geomagnetic tail. A combined power law and exponential is indicated. (UK)

**15194** GEOMAGNETIC DISTURBANCES AT CONJUGATE POINTS AND SOME EFFECTS OF SOLAR PLASMA ON THE MAGNETOSPHERE. Bobrov, M. S. (Astronomical Council, Moscow). Sov. Astron. AJ (Engl. Transl.); 13: 677-84(Jan-Feb 1970).

Translated from Astron. Zh.; 46: 862-71(Jul-Aug 1969).

The agreement (in UT) of the pattern of magnetic disturbances recorded at the Mirnyi and Murchison Bay polar-cap observatories for all days in 1958 was investigated. During January–April and September–December there was a strong diurnal variation of "agreement units" with a maximum near geomagnetic midnight and a minimum before geomagnetic noon. It is shown that the observed diurnal variation: (1) is unrelated to the relative rotation of the polarization plane during transfer of a disturbance between conjugate points; (2) is not the result of effects common to the entire Earth or the entire area of the polar caps; (3) indicates that the lines of force in the magnetic tail are not strictly parallel to the neutral layer, but with increasing distance from the Earth become closer and closer to the neutral layer. The nighttime agreement maximum indicates that during these hours the direct source of disturbance (a small region of the neutral layer situated at the site of its intersection by a tube of force) is usually common for both observatories of the pair. The tube of force connecting the pair is broken at the site of its intersection by the neutral layer, but the length of the break segment does not differ greatly from the thickness of the neutral layer at this point. The minimum during the forenoon hours is evidently due to the effect exerted on the tube of force by random movements of turbulent plasma in the space between the shock wave front and the magnetopause. During the period May–August (which stands out with respect to the number of large sporadic magnetic storms and chromospheric flares of very high intensity) there was a weakening of the nighttime agreement maximum; this can evidently be attributed to the injection of flare plasma into the neutral layer region and disruption of the geometry of the lines of force in the magnetic tail by this plasma. (auth)

**15195** TRANSIENT EMISSIONS ON THE WAVELENGTH OF HELIUM I, 5876 A RECORDED DURING AURORAL BREAKUP. Stoffregen, W. (Research Inst. of Swedish National Defence, Stockholm). Planet. Space Sci.; 17: 1927-35(Dec 1969).

During the breakup phase of two strong auroral events, emissions of short duration on the wavelength of neutral He, 5876 Å have been observed. These records are accurate within ~0.5 Å and intensities of up to 120 R have been measured. This high value is not consistent with the theoretical limit suggested by other authors. Simultaneous observations of Hα, 6563 Å show that the neutral He and Hα emissions are not closely related to each other with time, which may be one reason for explaining the discrepancy with the predicted intensity derived from observed ratios of $He^{++}/H^{+}$ in the solar wind. The emission on 5876 Å has only been detected at the lowest border of very intense ray bundles towards north but not yet in auroral arc and diffuse glow. It is suggested that two principally different helium events in aurora may be observable, one resulting in a low-level He emission lasting for longer time and another in a stronger He emission of short duration. The observational difficulties caused by the presence of OH bands are discussed. (auth) (UK)

**15196** CHANGES IN THE IONOSPHERIC F2 LAYER AT A PLACE NEAR THE S/sub q/-CURRENT FOCUS DURING GEOMAGNETIC STORMS. Jani, K. G.; Kotadia, K. M. (Gujarat Univ., Ahmedabad, India). Planet. Space Sci.; 17: 1949-59 (Dec 1969).

Hourly data of maximum electron density and total electron content in a unit column up to the level of peak electron density of the F2 layer at Puerto Rico (magnetic dip 52.5°N) in the American sector are studied to find their DS and $D_{st}$ variations and to compare them with those of the horizontal component of the Earth's magnetic field for 93 SC-type geomagnetic storms which occurred during the period September 1957–March 1962. These variations are obtained separately for positive and negative F2-storms and then averaged for all the types. It is found that the positive F2-storms are in a way connected with the equatorial type of DS variation of the H-field and the negative F2-storm with the high-latitude type DS variation of the H-field. The $D_{st}$ variation of the H-field is practically of the same character for both positive and negative F2-storms. These findings combined with those of others indicate that it is the DS current in the ionosphere that cause the observed changes in the F2-layer through electromagnetic movements; diffusion along the field lines and changes in the loss-rates of electrons may also contribute to the net effects. A statistical survey shows that while there are equal chances for positive F2-storms in Summer and Winter at Puerto Rico, there is a much larger number of negative F2-storms in Summer than in Winter. At a southern conjugate place, there is a much larger number of positive F2-storms in Winter, but equal number of negative F2-storms in Summer and Winter. More than half the total number of the F2-storms are found to be similar types (33 per cent positive, 23 per cent negative) from the consideration of the F2-changes during individual magnetic storms at the conjugate places. These are discussed in the concluding section of the paper. (auth) (UK)

**15197** SPATIAL AND TEMPORAL RELATIONS BETWEEN AURORAL EMISSION AND COSMIC-NOISE ABSORPTION. Gustafsson, Georg (Kiruna Geophysical Observatory, Sweden). Planet. Space Sci.; 17: 1961-75(Dec 1969).

An investigation has been made of the relation between auroral emission at λ5577 Å and the cosmic noise absorption using a new technique. A photometer and the antenna of a riometer were mounted on a 60 m long rotating antenna boom which had a speed of 1 rev per 3 min. The instruments were directed at an elevation angle of 45°. From the analysis of several break-ups of the aurora it has been found that during a period of 15–20 min in the middle of a break-up there may be an increase of the absorption by a factor 2 to 4 which does not correspond to a similar increase of the auroral emission. These changes in the emission–absorption ratio has been interpreted as peaks in the energy spectrum of the incoming particles. The structures of auroral emission and auroral absorption are sometimes very similar over periods of hours and the appearance of the structure is usually in the form of an east–west oriented arc. The cross correlation coefficient may be as high as 0.9 during these events over long periods of time. However, a number of exceptional cases have appeared where little structure was found in the riometer record while the photometer showed structure and vice versa. (auth) (UK)

## Low-Temperature Physics

*Refer also to abstracts 14121, 14127, 14134, 14136, 14148, 14757, 14778, 15049, and 15723.*

**15198** (IS-T-331) SPIN SCATTERING IN SUPERCONDUCTORS. Williams, Larry John (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 98p. Dep. CFSTI.

Thesis.

Thermal conductivity and single crystal neutron diffraction measurements were taken on La–Lu–Tb alloys in order to obtain information about the possible coexistence of superconductivity and an ordered magnetic impurity spin system. The neutron diffraction measurements were primarily intended to give information about correlations in the impurity spin system while the thermal conductivity results were primarily intended to provide information about the superconducting properties. The results of the neutron measurements were consistent with the interpretation that short range order is present at Tb concentrations of 10 and 20 at.%. Strong anisotropy fields hold the moments in the basal

plane. The short range order disappears at 5 at.% and local fields which arise from neighboring atoms cause the full Tb moments to line up in random directions in the basal plane. Large anomalies in the thermal conductivity, which were predicted theoretically by Bennemann as a result of correlations in the impurity spin system, were not observed in the $La_{2x}$ $Lu_{2-x}$ $Tb_x$ system. The transition temperatures for two magnetic impurity alloys in this system agreed with the predictions of Abrikosov and Gor'kov (AG) (based on paramagnetic impurities in a BCS like host) to better than 0.5%. These results are again consistent with an absence of magnetic order in the impurity spin system. The thermal conductivity measurements also imply that superconductivity in this system is not filamentary but rather it is a bulk phenomenon. (auth)

**15199** (JINR-P8-4785) INVESTIGATION OF THE SURFACE SHF-RESISTANCE OF THE SECOND TYPE SUPERCONDUCTORS. Rubin, N. B.; Sabaev, A. A.; Smirnov, Yu. I.; Khukhareva, I. S.; Shabratov, V. G. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1969. 16p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The surface SHF-resistance of the superconducting alloys of the Nb–Zr and Nb–Ti type has been investigated. The measurements were performed at 500 MHz in the external magnetic field of 40 to 50 kOe. Commercial superconductors performed as wires are used. The techniques and the results of experiment are described. (auth)

**15200** (LA-4259) FABRICATION OF POROUS COPPER HEAT EXCHANGER MEDIA FOR $^3$He–$^4$He DILUTION REFRIGERATORS. Sheinberg, Haskell; Steyert, William A. (Los Alamos Scientific Lab., N. Mex.). Aug 1969. Contract W-7405-eng-36. 3p. Dep. CFSTI.

Temperatures near absolute zero have been obtained with a $^3$He–$^4$He refrigerator. Preparation of porous copper heat exchanger media used in the refrigerator is described in detail. The fabricated porous copper is characterized by metallographic examination and by impedance to nitrogen flow. The refrigerator employing the porous copper has reached a temperature of 0.013°K (auth)

**15201** (NYO-2391-100) THE JOSEPHSON JUNCTION AS SOURCE OF FAR-INFRARED RADIATION. Report No. 1252. Elsley, Richard Keith (Cornell Univ., Ithaca, N. Y. Materials Science Center). Jan 1970. Contract AT(30-1)-2391. 33p. Dep. CFSTI.

Thesis.

Radiation produced by a Josephson junction located inside a resonant cavity was detected. Indirect evidence indicates that this radiation is in the far-infrared, at frequencies of from 2 $cm^{-1}$ to 13 $cm^{-1}$ (60 to 400 GHz). Power levels of up to $10^{-9}$ W were observed. (auth)

**15202** (UCSD-10-P-11-90) SUPERFLUIDITY OF $^3$He. Bookbinder, James Henry (California Univ., La Jolla, San Diego). Sep 1969. Contract AT-11-1-GEN-10. 220p. Dep. CFSTI.

The previous treatments of the question of superfluidity in $^3$He, which have not shown conclusively whether this phase should or should not occur, are summarized. The most promising calculation was by Pitaevskii, whose determination of the screened quasiparticle transition amplitude $\tilde{J}_j$ was carried out in the limiting case of large angular momentum j. In estimating $T_c$ this was extrapolated to j = 2 by Gor'kov and Pitaevskii (G.P.). The work of G. P. was found to contain an inadequate approximation (the D-wave Born approximation) plus also an algebraic error. When these corrections are made, their formula for $T_c$ then yields the unattainably low value $T_c \sim 10^{-100}$ deg. $\tilde{J}_j$ ($0 \leq j \leq 10$) was projected precisely in second-order perturbation theory. The off-energy-shell K-matrix was used as the bare vertex function, the particular form of which was chosen so that K would satisfy two exact identities (Ward Identities). It was found that G.P.'s extrapolation underestimates the effective D-wave interaction. In fact, the polarization (bubble) diagram is an attractive correction to $K_j$ for j = 2 and $j \geq 6$, in contrast to Pitaevskii's result that the second-order diagram for $\tilde{J}_j$ is repulsive. The three approximations involved in Pitaevskii's large-j calculation are studied carefully. Theoretical arguments are given, and numerical evidence is furnished, which indicate that as j increases his limit is being approached asymptotically, but so slowly that Pitaevskii's analytical result does not hold for angular moments of interest (i.e., for $j < 20$). The possibility of D-state superfluidity is discussed. The present work indicates that $T_c$ may be as high as $10^{-4}$ deg, but the transition temperature is such a sensitive function of the calculated theoretical parameters that it is difficult to furnish a precise estimate for $T_c$. To make the dissertation self-contained, and to carefully define the notation and terminology, the early chapters contain a summary of many-body techniques, K-matrix theory, and the theory of superconductivity. (auth)

**15203** THE EFFECT OF HEAT TREATMENT AND NITROGEN ADDITION ON THE CRITICAL CURRENT DENSITY OF A WORKED NIOBIUM 44 WT. PERCENT–TITANIUM SUPERCONDUCTING ALLOY. Baker, C. (Central Electricity Research Labs., Leatherhead, Eng.). J. Mater. Sci.; 5: 40-52(Jan 1970).

Mechanical working of a single phase superconducting alloy leads to an increase in the critical current density, $J_c$. After cold-rolling $J_c$ exhibits anisotropy as the angle of the magnetic field to the rolled surface is changed. The effects of interstitial addition and heat-treatment on $J_c$ and its anisotropy in both cold-rolled and wire-drawn alloy were studied. The variations in $J_c$ are correlated with the observed changes in the microstructure. (auth) (UK)

**15204** DESCRIPTION OF THE PHYSICAL BEHAVIOR OF SUPERCONDUCTORS. Ferrier, M. Ann. Mines; 11-33(Jan 1970). (In French).

The main properties of superconductors and the different theories defining their behavior are outlined. The microscopic theory is mentioned and phenomena responsible for superconductivity are disclosed. The electronic state corresponding to superconductivity is described and the influence of different parameters (density of states, Debye temperature, coupling constant) is pointed out. Using the Ginzburg–Landau theory, the main concepts are introduced: length of coherence, penetration depth, etc. Finally, details are given on the behavior of Type-II superconductors by describing the vortex lines, their interactions, their anchoring and the resulting microscopic properties (critical current, losses under ac conditions, flux jumps, etc). Basic parameters of superconducting materials are tabulated. (France)

**15205** NONLINEAR PRESSURE DEPENDENCE OF THE SUPERCONDUCTING TRANSITION TEMPERATURE OF COPPER SULFIDE CuS. Nakajima, Tetsuo; Isino, Masahiro; Kanda, Eizo (Tohoku Univ., Sendai). J. Phys. Soc. Jap.; 28: 369-74(Feb 1970).

The superconducting transition temperatures of copper sulfide CuS are measured as a function of hydrostatic pressure up to about 9 katm by an ice bomb technique. The superconducting transition is detected with the ac Hartshorn mutual inductance bridge. In contrast to ordinary superconductors, the curve of the shift of the transition temperature with increasing pressure decreases nonlinearly with downward curvature over the whole range of applied pressures and its slope changes discontinuously at about 3.5 katm. The maximum peak of the imaginary part of the ac susceptibility vanishes under pressures above about 1.6 katm. The unusual behavior of the transition temperature can probably be attributed to a change of the Fermi surface of the type proposed by Lifshitz. (auth)

**15206** SUPERCONDUCTIVITY OF TANTALUM–RHENIUM ALLOYS. Mamiya, Takayoshi; Nomura, Kousi; Masuda, Yoshika (Nagoya Univ., Japan). J. Phys. Soc. Jap.; 28: 380-9 (Feb 1970).

The new measurement of the specific heat of bcc 5d transition metal alloys of Ta–Re series containing up to 40 at. % of Re was made and the superconducting behavior of the alloys including up to 20 at. % of Re was studied. By making use of McMillan's theoretical treatment, the electron–phonon coupling constant and bare electronic density of states were deduced. The electron–phonon coupling constant, as a function of the number of electrons per atom, behaves in the same way as the density of states. This result suggests that the coupling constant is proportional to the bare density of states. The results of the density of states are compared with the theoretical ones deduced by Mattheiss for Ta and W. (auth)

**15207** SUPERCONDUCTIVITY BY SMALL POLARONS. Zinamon, Z. (Cambridge Univ., Eng.). Phil. Mag.; 21: 347-56(Feb 1970).

It is shown that the assumption that the carriers are small polarons can explain superconductivity in doped or reduced $SrTiO_3$ consistently with the existence of metallic conductivity at very low carrier densities. The attractive polaron–polaron interaction responsible for superconductivity is caused by polaron–intravalley acoustic phonon interaction, which in this model is only weakly screened by the Coulomb polaron–polaron interaction. (auth) (UK)

**15208** CALCULATION OF THE SOUND ABSORPTION IN SUPERFLUID HELIUM BELOW 0.6K. Jaeckle, Josef (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Z. Phys.; 231: 362-76(1970).

The sound absorption in superfluid helium is calculated using the renormalized perturbation expansion of the phonon self-energy. The second-order $\omega T^4$ result is derived without the assumption of a Lorentzian form of the phonon spectral function. The fourth-order contribution leads to better agreement with experimental data. These results are compared with simple perturbation theory. A discussion of the Boltzmann-equation approach is also given. (auth)

**15209** DOES A SUPERCONDUCTOR WITHOUT LONG-RANGE ORDER HAVE AN ENERGY GAP? Schmid, Albert (Stevens Inst. of Tech., Hoboken, N. J.). Z. Phys.; 231: 324-32(1970).

Marcelja's theory of a superconductor without long-range order is cast in a microscopic form. As a consequence, it is found that such a superconductor is gapless. Therefore, measurements of the tunneling density of states should provide a test of this theory; results of measurements are discussed here. (auth)

**15210** SUPERCONDUCTIVITY OF MOLYBDENUM. Pinatti, Daltro Garcia. Houston, Tex.; Rice Univ. (1969). 112p.

Thesis.

A quasi-static dynamic technique was developed in connection with the study of the superconductivity of Mo. The superconductor-to-normal transition and the reverse was studied, and its dependence on small variations in defect structure or impurity was established. Electrodynamic damping is proved to be the main controller of the transitions curves, and the trapped flux was shown to be concentrated in the center of the sample in a rather diffuse way. Supercooling properties were studied, and a decrease of the KAPPA factor with annealing time was established. KAPPA factors as low as $0.075 \pm 0.02$ were obtained. There is no indication that this is the limit, and it can be said that Mo, is together with Al, one of the softest superconductors known so far. A reformulation of the KAPPA factor concept for Type-I superconductivity is required in connection with extended defects. A promising method of residual resistivity measurement using the dynamic technique is exploited, and agreement with the potentiometric method is found. The method gives a resistivity increase as the temperature approaches $T_c$ from below, and this is not understood at the present moment. An approximate method of solution of the Ginsburg–Landau equations for an isolated vortex is studied. Final mathematical expressions for the parameters involved are found. Expressions for the differential and incremental entropy of a vortex are deduced, and agreement with experimental behavior is found. Forces due to thermal and order parameter gradients are computed from which a mechanism of flux expulsion is suggested. (Diss. Abstr. Int., B)

**15211** FAR-INFRARED STUDY OF SUPERCONDUCTORS CONTAINING MAGNETIC IMPURITIES. Dick, George John. Berkeley, Calif.; Univ. of California (1969). 58p.

Thesis.

A new far-infrared method was developed to study the energy-gap properties of a thin superconducting film containing magnetic impurities and thus capable of exhibiting gapless superconductivity The method allows the direct determination of the real part $\sigma_1$ of the conductivity of the superconductor by measuring calorimetrically the infrared radiation absorbed by the film. The systems studied were quenched films of lead containing either Gd or Mn impurities. The experimentally observed frequency-dependence of $\sigma_1$ (which exhibits the properties of the energy gap) is found to be distinctly different from that expected for nonmagnetic impurities. In the case of lead films containing Gd impurities, whose spins are due to 4f electrons, the behavior of $\sigma_1$ is in good quantitative agreement with the behavior predicted by Skalski et al., on the basis of the Abrikosov–Gorkov theory. In the case of lead films containing Mn impurities, whose spins are due to 3d electrons, the behavior of $\sigma_1$ is affected more drastically than predicted by this theory. These results agree with conclusions obtained in previous tunneling measurements on these systems. (Diss. Abstr. Int., B)

**15212** SVERKHPROVODYASHCHIE MAGNITNYE SISTEMY. (Superconducting Magnetic Systems). Kazovskii, E. Ya (ed.). Leningrad; Izdatel'stvo Nauka Leningradskoe Otdelenie (1967). 324p.

A brief review is given on the properties and applications of superconducting magnetic systems. Specifications for developing, designing, and selecting optimum materials and methods are discussed. Electric and thermal insulation materials for superconducting systems are reviewed. Uses of dc conductors, configurations of superconducting coils, current-carrying systems for superconducting installations, and properties of superconducting magnetic systems for transformers and generators are covered in several chapters. Cryostats are described in two separate chapters. Method of gas rarefaction, and technical and economical evaluation are made of various supermagnetic systems and other types of magnetic systems. Reference data are also included on the mechanical properties and strength of metals and plastics as well as properties of helium, hydrogen, nitrogen, and air. 350 references. (R.V.J.)

**15213** FLUX MOTION AND NOISE IN SUPERCONDUCTORS. van Gurp, G. J. (Technical Univ., Eindhoven, Netherlands). Philips Res. Rep. Suppl.; No. 5, 1-115(1969).

Thesis.

The dc and noise voltage across a superconductor caused by the motion of regions containing magnetic flux, viz. vortex lines or normal domains, is dealt with. It is shown from measurements of the dc voltage that pinning of vortex lines in type-II superconductors is dependent on the structure of the material and may be anisotropic. Anisotropy is caused in vanadium foils by the structure that is introduced by the rolling process and in indium-20% thallium monocrystalline wire by a martensitic transition resulting in parallel twin boundaries. Flux motion gives rise to a noise voltage due to the quantized nature of the moving flux. The power spectra have a cutoff frequency determined by the transit time of the flux. Measured power spectra are in reasonable agreement with theory, if it is assumed that there is a transit-time distribution. In type-II superconductors the flux moves as bundles of vortex lines. The size of the bundles decreases with increasing temperature, current density and magnetic field and after annealing. In type-I superconductors the noise is associated with the voltage component caused by flux motion and not with the voltage component caused by ohmic loss in immobile normal domains. At low fields the dependence of noise on external parameters is similar to type-II superconductors. At higher fields normal domains increase in size with increasing temperature, current density and field. Noise is also caused by temperature fluctuations associated with nucleate boiling in liquid helium I or pressure oscillations above liquid helium II. (auth)

**15214** RF SPUTTERING OF SUPERCONDUCTING MATERIALS. Hanak, Joseph J. (RCA Labs., Princeton, N. J.). pp 83-95 of Transactions of the Conference and School on the Elements, Techniques, and Applications of Sputtering, Brighton, England, October 20–22, 1969. London; Materials Research Company Ltd. (1969).

See CONF-691022.

A rf co-sputtering technique using two separate target materials on a single cathode plate was successfully used in obtaining films of two substances in which the composition varied continuously over a range of up to 80%. No apparent restriction was observed on the combination of target materials, including metals, semiconductors and insulators. The relative sputtering rate of a given target material in combination with another material remained essentially constant at a set rf power. The technique was applied to three different types of materials having superconducting properties, including metal-dielectric mixtures (cermets), immiscible metal mixtures and intermetallic compounds having the $\beta$–W structure. Formation of metastable solid solutions in the case of immiscible metals and intermetallic compounds was achieved. The use of this approach of materials synthesis and evaluation was shown to result in smooth variation of measured properties with composition. The extension of this technique of synthesis to other classes of materials and to three-component systems is obvious. 15 references. (UK)

**15215** STRUCTURE OF ELECTRON BUBBLES IN LIQUID HELIUM FROM PHOTO-EJECTION UNDER PRESSURE. Zipfel, Christie Lewis. Ann Arbor, Mich.; Univ. of Michigan (1969). 88p.

Thesis.

A critical experimental test of the bubble model of excess electrons in liquid helium is presented. In the bubble model an electron is self-trapped in a spherical cavity which appears to the electron as a spherical square well potential. If the model is correct, it should be possible to eject an electron from the bubble with a photon of the appropriate energy. This photo-ejection effect is detected in this experiment by observing changes in the mobility of negative charge carriers drifting in an electric field when light in the near infrared is focussed in the drift region. The cross section for this effect has been measured at pressures from 10.5 to 249 psi. These experimental cross sections have been compared with the theoretical cross sections for photo-ejection of an electron from a spherical square well of radius R and well depth $V_0$. It is possible by this comparison with the simple theory to assign a radius and well depth to the bubble at each pressure studied. The radius was found to vary from $14.75 \pm .05$ Å at 10.5 psi to $11.60 \pm .15$ Å at 230.5 psi. The well depth was found to vary from $0.60 \pm .02$ eV to $1.10 \pm .02$ eV over this pressure range. These values of the radius and well depth have been compared with theoretical predictions and with other experimental measurements. (Diss. Abstr. Int., B)

**15216** OSCILLATION OF SUPERFLUID HELIUM FILMS AND THIRD SOUND. Seiden, Joseph (CNRS, Orsay, France). Compt. Rend., Ser. B; 269: 677-80(13 Oct 1969). (In French).

A rigorous solution for the problem of low temperatures is given. It is shown that the theoretical ideas of Atkins and Khalatnikov regarding the third sound cannot be reconciled with the hydrodynamics of two fluids when the physical conditions for the film surface are correctly expressed. (J.F.P.)

**15217** ON THE ATTENUATION AND DISPERSION OF FIRST SOUND NEAR THE SUPERFLUID TRANSITION IN $^4$He. Ahlers, Guenter (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Low Temp. Phys.; 1: 609-31(Dec 1969).

Available measurements of the attenuation and dispersion of first sound near the superfluid transition in $^4$He are re-examined. Particular attention is given to the effort of the gravitational inhomogeneity upon the measurements, and the thermodynamic velocity is used to obtain the dispersion contribution from measured velocities at nonzero frequencies. The re-interpreted results are discussed in terms of current theories. Although there is partial agreement between experiment and theory, a number of aspects of the problem requires further theoretical and experimental investigation. (auth)

**15218** SURFACE RESISTANCE OF THIN-LAYER LEAD SUPERCONDUCTORS DEPOSITED BY ELECTROLYSIS. Septier, Albert; Salauen, Michel (CNRS, Orsay, France). Compt. Rend., Ser. B; 269: 685-8(13 Oct 1969). (In French).

The surface resistance of thin layers of lead obtained by electrolysis varies in an complex way with the current density used for the deposit. At 4.2°K, the experimental values obtained at 9000 and 3000 MHz are conformable with theoretical conjectures, but an important residual resistance appears at lower temperatures. (tr-auth)

**15219** ATOMIC ORDERING AND SUPERCONDUCTIVITY IN A15 COMPOUNDS. Blaugher, R. D. (Westinghouse Research Labs., Pittsburgh); Hein, R. E.; Cox, J. E.; Waterstrat, R. M. J. Low Temp. Phys.; 1: 539-61(Dec 1969).

Twenty-six different binary A15 compounds were investigated to determine if superconductivity could be related to the degree of long-range atomic ordering on the crystallographic lattice sites. Significant changes in the superconducting transition temperatures and critical fields were produced by quenching from high temperatures followed by low-temperature annealing. These changes in $T_c$ were accompanied by changes in the degree of long-range ordering as determined using x-ray diffraction methods. The results can be interpreted within the framework of Weger's "linear-chain" model only when the B element is a nontransition element. When both the A and B components are transition elements, however, the superconducting behavior will apparently depend on the nature of "d-electron" interactions between the component atoms. Complete ordering is not always an essential requirement for optimizing the superconducting properties. (auth)

**15220** CRITICAL MAGNETIC FIELD CURVE OF SUPERCONDUCTING TUNGSTEN. Black, W. C.; Johnson, R. T.; Wheatley, J. C. (Univ. of Illinois, Urbana). Contract AT(11-1)-1198. J. Low Temp. Phys.; 1: 641-67(Dec 1969).

The critical magnetic field of superconducting tungsten was measured as a function of temperature down to 3 mK. In common with other weak-coupling superconductors the agreement with the theoretical BCS curve is very good. The critical temperature $T_c$ of the specimen was found to be 15.4 ± 0.2 mK. Analysis of the low-temperature data gives the values 1.15 ± 0.01 G for $H_0$ and 0.90 ± 0.06 mJ/mole $K^2$ for the electronic specific heat parameter $\gamma$. Very large supercooling and superheating effects are observed for an electropolished specimen. The Ginzburg–Landau parameter estimated from the supercooling field is $\kappa = (2.6 \pm 1.6) \times 10^{-2}$. The problem of providing thermal contact at very low temperatures to the sample is discussed with emphasis on use of liquid $^3$He. (auth)

**15221** THEORY OF MAGNETIC IMPURITIES IN SUPERCONDUCTORS. I. EXACT SOLUTION OF THE NAGAOKA EQUATIONS. Zittartz, J.; Mueller-Hartmann, E. (Univ., Cologne). Z. Phys.; 232: 11-31(1970).

The Nagaoka Green's functions equations for a superconductor are solved exactly and the question of bound states within the gap is answered unambiguously. It is shown that there are always two bound states symmetrically located with respect to the center of the gap. For ferromagnetic coupling, $\gamma > 0$, and for antiferromagnetic coupling, but $T_K \gg T_{c0}$ or $T_K \ll T_{c0}$, these bound states are very close to the gap edges. For $T_K \sim T_{c0}$, however, the bound states move towards the center of the gap. It is pointed out that, in the latter case, important deviations from the Abrikosov–Gorkov theory, i.e. manifestations of the Kondo effect, should occur which could be tested experimentally by investigating the density of states. (auth)

**15222** CORRELATION OF THE CRITICAL SUPERCONDUCTING TRANSITION TEMPERATURE WITH THE CONDUCTION-ELECTRON CONCENTRATION IN V–Ga AND Nb–Ti ALLOYS. Golovashkin, A. I.; Levchenko, I. S.; Leksina, I. E.; Motulevich, G. P.; Shubin, A. A. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.); 10: 328-30(5 Dec 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu: 10: 515-17(5 Dec 1969).

The superconducting and optical properties of alloys of vanadium with gallium and of niobium with titanium were investigated. Samples of the following compositions were prepared: V–Ga with 70, 74, 85, 92, 93, 96, and 97 at. % V, and Nb–Ti with 25, 40, 52, 75, 85, and 100 at. % Nb. The V–Ga alloys have a B–W lattice, while the Nb–Ti alloys have a bcc lattice. The measurements revealed a correlation between $T_c$ and the conduction-electron density. It was found that $T_c$ increases with increasing effective electron–phonon collision frequency. (M.H.R.)

**15223** A THEORETICAL AND EXPERIMENTAL STUDY OF THE AC LOSSES OF A HIGH-FIELD SUPERCONDUCTOR AND THE IMPLICATIONS FOR POWER APPLICATIONS. Hanrahan, Donald Joseph. College Park, Md.; Univ. of Maryland (1969). 68p.

Thesis.

A theory for the hysteresis loss of a high-field superconductor carrying ac is presented, based on the Riemersma critical state model ($B \times J = C$). Voltage waveforms, energy loss per cycle, and limiting values of effective resistivity are derived. For sinusoidal current of frequency f in 10-mil wire, the high (critical) current limit of resistivity is found to be $4.06 \times 10^{-14}$ f (ohm-meter) compared to $0.93 \times 10^{-16}$ f for a current peak of one-tenth the critical current; both values are independent of the high-field material used. An equivalent circuit consisting of a variable inductance is proposed for the hysteretic superconductor and three possible definitions of the inductance are discussed. Experiments were performed at 4.2°K on bifilar windings of 10-mil, Nb–25% Zr wire, both bare and copper-plated. Currents up to the critical value were used at frequencies of 60, 400, and 800 Hz. A compensation technique was employed to obtain the voltage due to internal magnetic field; oscillograms of the corresponding vol–amp characteristic and various waveforms were made. Current and compensated voltage waveforms were used to calculate the loss per cycle. Oscillograms were in fair agreement with theoretical waveforms. Critical currents decreased with frequency, and the copper-plated wire had consistently higher values than the bare wire, although losses were higher for the copper-plated wire. There was some-quantitative agreement between the experimental plated-wire loss and that calculated from the theory, but the measured bare-wire loss was generally less than that predicted by the theory, based on a measured critical current. The effective resistivity was found to vary as $f^{0.42}$, which fits neither an eddy-current theory nor the simple hysteresis model used. The feasibility of applying superconductivity to two classes of ac power equipment is discussed: (1) conventional apparatus such as transformers and rotating machines, already highly efficient, and (2) low-voltage static inverters which are not so efficient. (TSS) (Diss. Abstr. Int., B)

**15224** SUM RULES AND THEIR APPLICATION IN THE THEORY OF SUPERFLUID HELIUM. Szepfalusy, P. (Roland Eoetvoes Univ., Budapest). Acta Phys. Acad. Sci. Hung.; 27: 299-307(1969).

Static response functions of superfluid helium in the hydrodynamic region are investigated, which results in obtaining a new sum rule. Sum rules are then specialized to zero temperature and exploited to determine matrix elements of the particle creation and annihilation operators between the ground state and the one quasi-particle state in the long-wavelength limit. The particle distribution function is examined and, besides calculating the leading term, a lower limit is given to the next one in the expansion for small wave numbers. (auth)

**15225** SUPERCONDUCTIVITY AND MAGNETISM OF LANTHANUM–RARE EARTH DIALUMINIDES. Maple, Merrill Brian. San Diego, Calif.; Univ. of California (1969). 126p.

Thesis.

Magnetic rare earth (RE) impurities depress the superconducting transition temperature ($T_c$) of the intermetallic compound $LaAl_2$ in a manner similar to that previously observed for elemental La. From the initial rate of depression of Tc of $LaAl_2$, a relative s-f coupling parameter $|J_{sf}|$ has been determined for the rare earths. This is compared with the relative $|J_{sf}|$ derived from NMR and EPR measurements on the isostructural (RE)$Al_2$ compounds. The experimentally determined superconducting-normal phase boundary of the $La_{1-x}Gd_xAl_2$ system (curve of $T_c$ versus magnetic solute concentration) is in excellent agreement with the theoretical prediction of Abrikosov and Gor'kov to concentrations very near the critical concentration ($n_{c_r}$). The agreement is better than in any other known system. Normal state magnetic susceptibility measurements on $La_{1-x}Gd_xAl_2$ alloys above $n_{c_r}$ indicate ferromagnetic order. The ferromagnetic-normal phase boundary (curve of ferromagnetic ordering temperatures versus magnetic solute concentration) does not appear to intersect the superconducting-normal phase boundary at an appreciable temperature. The depression of

$T_c$ of $LaAl_2$ by Ce impurities is anomalously large. Moreover, the dependence of $T_c$ on pressure for $La_{1-x}Ce_xAl_2$ alloys varies markedly with Ce concentration, whereas it is independent of Gd concentration in the $La_{1-x}Gd_xAl_2$ system. Anomalous behavior occurs also in the normal state properties of $La_{1-x}Ce_xAl_2$ alloys: the magnetic susceptibility deviates from Curie–Weiss behavior at low temperatures, and minima are observed in the low temperature electrical resistivity. These anomalies are discussed in terms of interband mixing of Ce 4f states with conduction band states. The effect of crystal fields is also discussed and reference is made to the magnetic susceptibility and electrical resistivity of $CeAl_2$. $CeAl_2$ is antiferromagnetic with a Neél temperature of ~3.5°K. (Disser. Abstr.)

**15226** QUANTUM FLUIDS AND NUCLEAR MATTER. Eleventh Boulder Summer Institute for Theoretical Physics, Boulder, Colorado, June 17–August 23, 1968. Mahanthappa, Kalyana T.; Brittin, Wesley E. (eds.). Lectures in Theoretical Physics. Volume XI-B. New York; Gordon and Breach, Science Publishers, Inc. (1969). 438p. (CONF-680727–(Pt.3)).

Ten papers are included. Separate abstracts were prepared for each. (M.H.R.)

*For abstracts of individual papers see: 15227–15233 and 16006–16008.*

**15227** SELECTED TOPICS IN THE THEORY OF NORMAL FERMI LIQUIDS. Pethick, C. J. (Univ. of Illinois, Urbana). Lect. Theor. Phys.; 11-B: 187-251(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727–(Pt.3).

Topics covered are: Landau's theory of normal Fermi liquids, the quasiparticle transport equation, excitations in normal Fermi liquids—their structure and interactions, transport coefficients in the low-temperature limit, a history of finite-temperature contributions to the properties of normal Fermi liquids, transport coefficients at finite temperatures, the specific heat at finite temperatures, and how paramagnons differ from phonons. (M.H.R.)

**15228** TOPICS IN THE THEORY OF LIQUID HELIUM FOUR. Chester, G. V. (Cornell Univ., Ithaca, N. Y.). Lect. Theor. Phys.; 11-B: 253-96(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727–(Pt.3).

The topics covered are: the ground state of liquid helium-4, the excitation spectrum of liquid helium, the rotation of liquid helium, Bose–Einstein condensation and liquid helium-4, and Bose–Einstein condensation in small systems. (M.H.R.)

**15229** ASPECTS OF THE $^4$He PROBLEM EMPHASIS ON DENSITY CORRELATIONS. Puff, R. (Univ. of Washington, Seattle). Lect. Theor. Phys.; 11-B: 297-320(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727–(Pt.3).

An attempt is made to tie together some aspects of the $^4$He problem without getting too deeply involved with the peculiarities of the microscopic dynamics for condensed Bose system. The properties calculated and measured for any many-body system and how they are supposed to be recognizably different for low-temperature $^4$He are discussed. These properties are considered in two categories: static equilibrium properties and responses to external probes. (M.H.R.)

**15230** THEORY OF VORTICES AND ROTATING HELIUM. Fetter, Alexander L. (Stanford Univ., Calif.). Lect. Theor. Phys.; 11-B: 321-70(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727–(Pt.3).

The topics covered are: the dynamics of vortices, the statistical mechanics of vortices, vortex oscillations, vortex dynamics in an imperfect Bose gas, and the interaction between vortices and elementary excitations. (M.H.R.)

**15231** CALCULATIONS OF THE BINDING ENERGY AND OTHER PROPERTIES OF LIQUID $^3$He AT ZERO TEMPERATURE. Oestgaard, E. (Princeton Univ., N. J.). Lect. Theor. Phys.; 11-B: 371-89(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727–(Pt.3).

The binding energy of liquid $^3$He is estimated by separate calculations of the two-body and the three-body interaction energy. The two-body contribution is calculated by Brueckner theory, using a modified Brueckner–Gammel method. The approximation of a reference energy spectrum with an effective mass and quadratic momentum dependence is used for the input single-particle energy spectrum. The intermediate-state potential energies off the energy shell are chosen to be equal to zero, and the outer self-consistency requirement in the Brueckner method is neglected. A self-consistent solution is obtained, however, by the requirement that the input and the output energy spectrum for particles on the energy shell in the Fermi sea shall give the same two-body interaction energy. The three-body contribution to the binding energy is estimated separately by methods originally developed for nuclear-matter calculations by Bethe and collaborators. Only the S-wave is properly taken into account. Other low-temperature properties, such as the compressibility, the coefficient of thermal expansion, and the magnetic susceptibility, are estimated, with results in fair agreement with experimental values. (M.H.R.)

**15232** QUANTUM STATISTICAL THEORY OF THE DEGENERATE BOSE FLUID. Shea, Dion W. J. (Creighton Univ., Omaha, Neb.). Lect. Theor. Phys.; 11-B: 391-406(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727–(Pt.3).

The results of some recent work on the application of quantum statistical techniques to the determination of the thermodynamic properties of a system of interacting bosons at temperatures below the Bose–Einstein condensation temperature are reported. Explicit expressions for calculating these thermodynamic properties were determined. All of the results are expressed in terms of a double-quasiparticle notation in which there are two quasiparticle energies possible for a given quasi-particle momentum. In order to bring the calculated expression for the entropy into agreement with Nernst's theorem, the grand canonical ensemble was modified into what is called the Q ensemble. (M.H.R.)

**15233** ORDERED SYSTEMS IN FINITE AND PARTIALLY FINITE GEOMETRIES. Krueger, David A. (Univ. of Wisconsin, Madison)Lect. Theor. Phys.; 11-B: 407-28(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727–(Pt.3).

The order parameter characterization of "super" systems is reviewed. The generality and limitations of a general theorem based on the Bogolyubov inequality which shows that in some geometries the order parameter must be zero for all nonzero temperatures are investigated. A possible modified criterion for "super" behavior is discussed in the context of an ideal Bose gas in a partially finite geometry. The dependence of measurable quantities on the number of particles in the system is investigated for several models. In some cases the $N \to \infty$ limit is approached very slowly. The ideal Bose gas in a finite geometry is discussed. (M.H.R.)

**15234** WAVE PROPAGATION IN A SUPERCONDUCTING CYLINDRICAL GUIDE. Zepp, Gerard (Univ., Clermont-Ferrand, France). Compt. Rend., Ser. B; 270: 30-2(5 Jan 1970). (In French).

The propagation of an electromagnetic wave of $TM_{01}$ mode and a wave of $TE_{01}$ mode in a superconducting cylindrical guide is studied. The coherence length of the superconducting material should be high. (France)

**15235** CALCULATION OF SUPERCONDUCTING PARAMETERS OF 18 NONTRANSITION METALS AND PRESSURE EFFECTS. Kakitani, Toshiaki (Osaka Univ.). Progr. Theor. Phys. (Kyoto); 42: 1238-64(Dec 1969).

Superconducting parameters of 18 nontransition metals were calculated using quite simple formulas obtained by solving the gap equations of Eliashberg. In the numerical calculation, the Umklapp process of the electron-phonon interaction was taken into account. It is found that only Li, Be, and Mg are superconductors among alkali and alkali earth metals. For Zn, Cd, β-Hg, In, Tl, Sn(w), Al, and Pb, calculated values of the critical temperature agree with those of experiments in the order of magnitude. Pressure effects for the critical temperature and the critical field are calculated, and it is found that they chiefly depend upon the pressure dependence of the phonon frequency. Calculated values are in good agreement with experimental data. Superconductivity under the very high pressure is also discussed. (auth)

**15236** A REMARK ON THE FLUX-FLOW RESISTIVITY OF DIRTY TYPE-II SUPERCONDUCTORS. Ebisawa, Hiromichi; Takayama, Hajime (Tokyo Univ.). Progr. Theor. Phys. (Kyoto); 42: 1481-3(Dec 1969).

The way the gauge covariant dynamical order parameter is obtained by Caroli and Maki [Phys. Rev. 159: 306 (1967)] is examined and it is found that their approach is incorrect. The discussion is confined to the linear order of the electric field which is sufficient for the calculation of the flux-flow resistivity. (M.H.R.)

**15237** PROBLEMS RELATED TO THE PRODUCTION OF NIOBIUM–TITANIUM BASED SUPERCONDUCTING ALLOYS. Bidault, M.; Dosdat, J. (Thomson CSF, Chatou, France). Ann. Mines; 57-65(Jan 1970). (In French).

The influence of deformation rates and heat treatments on the

maximum current densities that can be applied to niobium–titanium alloys is pointed out. For their utilization, these alloys must be set into copper or aluminum matrices which provide mechanical resistance and protection should an accidental transition of superconducting to normal state occur. Different examples of cables or ribbons containing a great number of niobium–titanium conductors having diameters of several microns and carrying current densities of 40,000 A/cm$^2$ in a magnetic field of 5 teslas, are given. (France)

**15238** ELECTRICAL CONDUCTIVITY OF A SUPERCONDUCTOR. Masker, W. E.; Marcelja, S.; Parks, R. D. (Univ. of Rochester, N. Y.). Phys. Rev.; 188: 745-54(10 Dec 1969).

A model is proposed that describes the dc electrical conductivity of a superconductor both above and below the classical critical point. The approach is to include in the calculation of superfluid density and the electrical conductivity the effect of the fourth-order term of the Ginzburg–Landau theory, which represents the interaction between superfluid excitations. The resulting expression for the conductivity simplifies to the Aslamazov–Larkin result above $T_c$ and yields, for "two-dimensional" samples, an exponential dependence of the superfluid conductivity on $\Delta T$ ($= T_c - T$) below $T_c$. Calculated results for the one- and three-dimensional cases are also given. Experimental studies of the electrical conductivity of "two-dimensional" Al films were made to test the model. Good agreement was obtained in the region below $T_c$, even when the sample resistance was followed over five decades and sample mean free paths were varied over two decades. (auth)

**15239** p-STATE PAIRING AND SUPERCONDUCTIVITY OF MONOVALENT METALS. Appel, J.; Heyszenau, H. (Gulf General Atomic Inc., San Diego, Calif.). Phys. Rev.; 188: 755-8(10 Dec 1969).

The superconducting transition temperature $T_p$ for electron pairs in triplet spin states with relative angular momentum $l = 1$ is calculated for simple metals. From a theoretical estimate of $T_p$ for Na and K, it appears that superconductivity cannot be ruled out at millidegrees Kelvin in ultrapure Na [with a resistance ratio $\rho(273°K)/\rho(4.2°K) \sim 10^3$]. (auth)

**15240** LATTICE THERMAL CONDUCTIVITY OF SUPERCONDUCTING NIOBIUM CARBIDE. Radosevich, Lee G. (Univ. of Illinois, Urbana); Williams, Wendell S. Contract AT(11-1)-1198. Phys. Rev.; 188: 770-3(10 Dec 1969).

The unusually low lattice thermal conductivity of the transition-metal carbides at low temperatures has been attributed to the scattering of phonons by conduction electrons. An experiment which confirms this interpretation is reported. Thermal conductivity measurements on single-crystal $NbC_{0.98}$ through its superconducting critical temperature (9.8°K) show that the lattice component of the thermal conductivity, $K_{ls}$, increases greatly below $T_c$ because of decreased phonon–electron scattering. The maximum increase in lattice thermal conductivity from this effect occurs at 3°K with $K_{ls}/K_{ln}$ equal to 160. The theories of Bardeen, Rickayzen, and Tewordt and of Klemens and Tewordt for the influence of electrons and point defects on lattice conductivity provide a quantitative interpretation of the effect. The best fit to the $NbC_{0.98}$ data is for $2\epsilon(o)/kT_c = 4.0$. The behavior of $NbC_{0.98}$ is in contrast to that of $NbC_{0.76}$, which remains in the normal state throughout the temperature interval studied and shows no increase in thermal conductivity. (auth)

**15241** MECHANISMS OF LOW-FIELD FLUX-FLOW RESISTANCE IN TYPE-II SUPERCONDUCTORS. Chow, W. S. (Univ. of Cincinnati). Phys. Rev.; 188: 783-5(10 Dec 1969).

On the basis of the Bardeen–Stephen (BS) theory, the behavior of flux-flow resistivity of type-II superconductors in the low-magnetic-field region and at finite temperatures is studied. The original BS theory does not include the interaction between flux lines. It is shown that if, in the local model, the penetration of the electric fields due to the surface charge distribution of one normal core into the normal-core regions of its neighboring flux lines, in the low-field region, is taken into account, then one obtains a relation between the flux-flow resistivity and the magnetic field, $\rho_f/\rho_n = H/H_{c2}(o) + \gamma H^2/H_{c2}(o)H_{c2}(T)$, with $\gamma$ depending on the structure of the flux-line lattice. This relation agrees, qualitatively, very well with experimental data. (auth)

**15242** TRANSMISSION OF FAR-INFRARED RADIATION THROUGH THIN FILMS OF SUPERCONDUCTING AMORPHOUS BISMUTH AND GALLIUM AND BETA-PHASE GALLIUM. Harris, Richard E.; Ginsberg, D. M. (Univ. of Illinois, Urbana). Phys. Rev.; 188: 737-44(10 Dec 1969).

The ratio $T_s/T_n$ of the far-infrared radiation transmitted through a thin film in the superconducting state to that transmitted through it in the normal state was measured at 1.1°K for thin-film samples of amorphous bismuth and gallium and samples of partially annealed ($\beta$-phase) gallium. The transition temperature $T_c$ of each film was also measured. The sample thicknesses were approximately in the range 50 to 200 Å. Numerical calculations based on the strong-coupling theory of superconductivity and on tunneling data produced theoretical values of $T_s/T_n$ which were in reasonably good agreement with the experimental results. The only adjustable parameter was the energy-gap width $2\Delta_0$. The quantities $T_c$ and $2\Delta_0$ decrease with increasing film resistance. The shift in $T_c$ was previously observed by Naugle and Glover in amorphous bismuth and gallium. The abrupt resistance change in these materials at about 19°K, which is characteristic of thicker amorphous films, appeared instead as a more gradual change in resistance, beginning at higher temperatures. (auth)

**15243** ELASTIC PROPERTIES OF SUPERCONDUCTORS: Nb, V, AND Ta. Goodrich, G. W.; Lange, J. N. (Oklahoma State Univ., Stillwater). Phys. Rev.; 188: 728-36(10 Dec 1969).

The magnetic field dependence of Young's modulus of type-I and type-II superconductors is used to study the properties of the intermediate and mixed states. The density and separation of vortices in the mixed state are computed from the observed field dependence of the elasticity by use of a model which allows the vortex to expand. A residual stiffness associated with trapped flux is observed to decrease at lower temperatures as a result of reduced pinning forces acting on the vortices. The pinning forces appear to be associated with more than elastic coupling done to the imperfections. The largest total change in stiffness due to the superconducting transition is associated with the longest normal-electron mean free path. Shielding of the lattice interactions in the superconducting state appears to be more effective the longer the coherence of the superconducting pairs between scatterings. Use of elastic measurements as a means of determining bulk characteristics of the superconductor is found to be quite accurate for materials with low acoustic losses. Anisotropies in the bulk critical fields of niobium are determined simultaneously with the magnetization. (auth)

**15244** THERMAL CONDUCTIVITY OF SUPERCONDUCTING Th AND Th–Gd ALLOYS. Cappellett, R. L.; Finnemore, D. K. (Ames Lab., Iowa). Phys. Rev.; 188: 723-8(10 Dec 1969).

Thermal conductivity measurements are reported for both the normal and superconducting states of pure Th and Th–Gd alloys. The pure Th results show significant deviations from the Bardeen–Rickayzen–Tewordt theory, but these deviations are consistent with the observed anisotropy of the energy gap. Measurements for the Th–Gd alloys agree well with the theory of Ambegaokar and Griffin for paramagnetic-impurity-doped superconductors. (auth)

**15245** ELECTRON TUNNELING INTO SUPERCONDUCTING MERCURY FILMS AT TEMPERATURES BELOW 0.4°K. Hubin, W. N.; Ginsberg, D. M. (Univ. of Illinois, Urbana). Phys. Rev.; 188: 716-22(10 Dec 1969).

The tunneling characteristics of aluminum/aluminum-oxide/mercury junctions were measured at temperatures down to 0.35°K. Structure was observed in addition to that seen in an earlier higher-temperature experiment. The data have been analyzed by a computer program written by McMillan and based on the strong-coupling theory. The tunneling density of states, the effective phonon spectrum, the complex energy-gap function, and the electron renormalization function were determined for mercury. The effective electron–phonon interaction constant and the first and second moments of the effective phonon spectrum were also determined. (auth)

**15246** CRITICAL VELOCITIES OF PERSISTENT CURRENTS OF SUPERFLUID HELIUM. Weaver, J. C. (Yale Univ., New Haven). Phys. Lett.; 31A: 97-8(9 Feb 1970).

Linear critical velocities of superfluid helium are measured directly by determining the maximum persistent superfluid velocities in narrow annular channels. (auth)

**15247** INEQUALITY FOR THE COHERENCE LENGTH IN He II NEAR $T_\lambda$. Szepfalusy, P. (Institut Max von Laue-Paul Langevin, Garching, Ger.). Phys. Lett.; 31A: 126-7(9 Feb 1970).

An inequality for the coherence length in superfluid helium near the lambda point is derived, which provides a lower bound depending on the value of the critical exponent of the order parameter. (auth)

**15248** STRONG-COUPLING PARAMETERS FOR SUPERCONDUCTORS. Laibowitz, R. B.; Sadagopan, V.; Seiden, P. E. (Thomas J. Watson Research Center, Yorktown Heights, N. Y.). Phys. Lett.; 31A: 133-5(9 Feb 1970).

It was observed that the change in $2\Delta/kT_c$ from its BCS value of 3.5 is exponentially related to $T_c/\theta_D$. (auth)

**15249** DYNAMICS OF VORTEX RINGS. Roberts, P. H.; Donnelly, R. J. (Univ. of Oregon, Eugene). Phys. Lett.; 31A: 137-8(9 Feb 1970).

It is shown that vortex rings with constant circulation can be described by an energy such that the velocity and impulse of the rings are connected by the usual relation $v = \partial E/\partial p$. This means that in superfluid helium a vortex ring may be regarded as a quasi-particle excitation. (auth)

**15250** ENERGY LEVELS NEAR THE SURFACE IN DILUTE MIXTURES OF LIQUID $^4$He IN $^3$He. Laheurte, J. P.; Manchester, F. D. (Univ. of Toronto). Phys. Lett.; 31A: 152-3(9 Feb 1970). (In French).

It is suggested that there is evidence for impurity levels existing near the surface of dilute $^4$He in liquid $^3$He mixtures and that this can explain the appearance of a superfluid film at a temperature above that of phase separation. (auth)

**15251** TRANSITION ANOMALIES OF DISORDERED ALUMINUM FILMS. Grassie, A. D. C. (Univ. of Sussex, Brighton, Eng.); Green, D. B. Phys. Lett.; 31A: 135-6(9 Feb 1970).

Excess resistance of up to 10% of the normal state value have been observed in the superconducting transition regions of disordered aluminum films. (auth)

**15252** DYNAMICS OF DISLOCATION DIPOLE MOTION IN THE FLUX LINE LATTICE OF TYPE-II SUPERCONDUCTORS. Kramer, Edward J. (Cornell Univ., Ithaca, N. Y.). J. Appl. Phys.; 41: 621-9(Feb 1970).

The motion of flux line dislocation (FLD) dipoles is shown to be a more important mechanism for flux transport than the motion of individual FLDs. The electric field generated by FLD dipoles moving at a terminal velocity v is $E = (Bby_s)Av$, where B is the magnetic induction, b is the magnitude of the Burgers vector, $y_s$ is the separation between the individual FLDs in each dipole, and A is the density of moving FLD dipoles. The terminal velocity is found to be proportional to $(J - J_c)$, where $J_c$ is a critical current density. The analogy between and above equation and the corresponding equation for the plastic-shear strain rate in metals is explored in order to qualitatively explain yield phenomena and time-dependent hysteresis in E–J curves. Possible FLD dipole sources and the portion of experimental E–J curves likely to be affected by FLD motion are also discussed. (auth)

**15253** EVIDENCE AGAINST THERMAL ACTIVATION AS THE CAUSE OF FLUX CREEP IN TYPE II SUPERCONDUCTORS. Wade, J. M. A. (Royal Society Mond Lab., Cambridge, Eng.). Phil. Mag.; 20: 1107-14(Dec 1969).

Voltage–current measurements have been made on lead–indium alloys in transverse magnetic fields with a voltage sensitivity of $10^{-12}$ V. By working in fields just below $H_{c2}$ it has been possible to observe the truly exponential dependence of voltage on current which is characteristic of flux creep. The expected temperature dependence of the creep rate, however, appears to be completely absent and it is therefore deduced that the creep does not result from thermal activation. Re-examination of earlier work does not show any clear contradiction of this view, and suggests furthermore that thermally activated creep is a most improbable process. (UK) (auth)

**15254** INVESTIGATION OF THE BREAKDOWN OF SUPERCONDUCTIVITY OF RIBBONS BY ALTERNATING CURRENTS. Totubalin, V. N. (Physical-Technical Inst., Leningrad). Prib. Tekh. Eksp.; No. 4, 121-4(Jul-Aug 1969). (In Russian).

The apparatus for oscillographing the process of transition of ribbons from superconducting to normal under the action of pulsed delta-shaped currents and alternating currents of 200 to 20,000 Hz was described. The duration of the pulse front was from 0.1 to 1.5 msec and amplitudes up to 40 amps. Compensation of self-induction emf permits the measurement of ohmic resistances of the order of several μohms with inductances of $10^7$ Henry. (tr-auth)

**15255** SUPERCONDUCTIVITY AND SPECIFIC HEAT OF ALLOYS BASED ON $Ti_3Sb$. Junod, A.; Heiniger, F.; Muller, J.; Spitzli, P. (Univ., Geneva). Helv. Phys. Acta; 43: 59-66 (16 Feb 1970). (In French).

The superconducting transition temperature, Debye temperature, and the normal electronic specific heat have been investigated in the quasi-binary alloys with A 15-type structure belonging to the systems Ti–Nb–Sb and Ti–V–Sb. Superconductivity has been discovered in single-phased, off-stoichiometric $Nb_{3-x}Sb$. The change of the transition temperature as a function of annealing conditions and order in $Ti_3Sb$ appears to be due to variations of the band structure. (auth)

**15256** STRUCTURE OF VORTICES IN SUPERCONDUCTIVITY. Leplae, L.; Mancini, F.; Umezawa, H. (Univ. of Wisconsin, Milwaukee). Lett. Nuovo Cim.; 3: 153-8(29 Jan 1970).

It was shown previously that the properties of a superconducting system are described mainly by bosons that appear in the theory as bound states of quasi electrons. The results obtained by applying this formulation to the problem of vortices are presented. A detailed account of the calculations will be published elsewhere. (M.H.R.)

**15257** THEORY OF THE ONSET OF SUPERFLOW. Roberts, Paul H.; Donnelly, Russell J. (Univ. of Oregon, Eugene). Phys. Rev. Lett.; 24: 367-71(23 Feb 1970).

Spontaneous production of quantized vortices in He II by thermal fluctuations is considered. Implications of this theory for superflow in finite channels are discussed. (auth)

**15258** DIVERGENT FLUCTUATIONS IN SUPERCONDUCTING FILMS. Crow, J. E. (Brookhaven National Lab., Upton, N. Y.); Thompson, R. S.; Klenin, M. A.; Bhatnagar, A. K. Phys. Rev. Lett.; 24: 371-5(23 Feb 1970).

Anomalously broad resistive transitions in superconducting films were observed and it was shown that the widths gradually reduce to the usual Aslamazov–Larkin value when a magnetic field is applied parallel to the film. These results are explained by adding to the Aslamazov–Larkin theory another fluctuation contribution to the conductivity of the type first proposed by Maki, which for thin films is logarithmically divergent with a cutoff proportional to the pair-breaking interactions. (auth)

**15259** THE SYNTHESIS, STRUCTURE, AND SUPERCONDUCTING PROPERTIES OF NEW HIGH-PRESSURE FORMS OF TIN PHOSPHIDE. Donohue, P. C. (E. I. du Pont de Nemours and Co., Wilmington, Del.). Inorg. Chem.; 9: 335-7(Feb 1970).

Reactions of Sn and P in a tetrahedral anvil press at conditions ranging from 15 to 65 kbars and 600 to 1300°C gave intimate mixtures of two forms of SnP: a tetragonal form having cell dimensions $a = 3.831 \pm 0.001$ Å and $c = 5.963 \pm 0.001$ Å and a cubic rock salt type having $a = 5.5359 \pm 0.0001$ Å at 25°C. The crystal structure of the tetragonal phase was refined from powder diffraction intensity data and shown to be similar to that of high-pressure GeP and GeAs. The tetragonal form transformed slowly and irreversibly to the cubic form when heated at ambient pressure between 100 and 200°C. Meissner-effect measurements showed the tetragonal form to be normal to 1.25°K and the cubic form to be superconducting between 2.8 and 4.0°K. (auth)

**15260** COUPLING BETWEEN PRESSURE AND TEMPERATURE AMPLITUDES IN WAVES OF SECOND SOUND IN LIQUID HELIUM. Hofmann, A.; Keck, K.; Schubert, G. U. (Institut fuer Theoretische Physik, Mainz). Z. Phys.; 231: 177-92(1970).

A very sensitive microphone suitable for acoustic measurements in liquid helium is described. With the use of it, both the pressure amplitude of second sound and the amplitude of first sound radiated from the second-sound transmitter (carbon layer heater) can be detected. By a special extension of the reciprocity theory the first sound pressure response of the microphone and the second sound transmitter response can be measured. The measured pressure signals of first and second sound are compared with the results of the two-fluid theory. (auth)

**15261** METHOD FOR MEASURING THE TIME-DEPENDENCE OF TEMPERATURE IN SUPERCONDUCTING FILMS. Kraus, H. NTZ-Nachrtech. Z.; 22: 713-15(1969). (In German).

A simple and accurate method for measuring periodically varying temperatures of superconducting films is described. The method is particularly suitable for measuring high-speed changes in temperature. The basic principle of this method is to scan the time-dependent critical current, which is a function of temperature to be measured, by the aid of a short current pulse, whose time position and amplitude are varied. This method was applied to a superconducting miniature stripline consisting of a thin evaporated tin strip and a groundplane of lead. Striplines of this type are used for gate lines of in-line cryotrons. By current pulses, whose amplitude exceeded the critical value, the tin strip was heated up periodically to temperatures lying above the transition point; the decay curve of these temperature rises was measured. The section of the decay curve lying above the transition temperature is estimated by calculation under the assumption of an adiabatic heating process. (auth)

## Plasma and Thermonuclear Physics

*Refer also to abstract 14363.*

**15262** FIZIKA GAZORAZRYADNOI PLAZMY. VYPUSK 2. (Physics of Gas-Discharge Plasma. Issue 2). Trekhov, E. S. (ed.). Moscow; Atomizdat (1969). 200p.

Nineteen articles are included on theoretical and experimental

data on physical processes in gas-discharge and thermal plasmas. Processes in molecular gases at atmospheric pressures, generation of dense plasma in high-frequency plasmatrons, and measurements of parameters of various compositions of plasma are investigated. Results obtained on emission and performance of gas-discharge sources were used for determining the absolute magnitudes of the squares of matrix elements of electron transition dipole moments and their relationship to the internuclear distances in important molecular systems of the molecules forming the air. The rate of nitrogen oxide dissociation at high temperature and erosion processes of metallic electrodes in strong currents of plasma injectors are also discussed. (R.V.J.)

## Confinement and Heating

**15263** (CONF-680466) PROCEEDINGS OF THE FIRST ALL-UNION CONFERENCE ON PLASMA CONFINEMENT IN CLOSED MAGNET SYSTEMS, MOSCOW, FIAN, 15–19 APRIL 1968. (Akademiya Nauk SSSR). Translation of report KHFTI-69-29. 117p. Dep. CFSTI.

The following papers are included: (1) plasma confinement in Tokamak, (2) plasma instability, (3) plasma confinement in toroidal systems, (4) closed magnetic configurations and their stability, (5) contemporary state of experimental research on plasma confinement in stellarators, (6) transport processes in toroidal systems, (7) development of magnetic surfaces and methods of their study in stellarators, (8) plasma in Tuman device, (9) magnetic system of Uragan stellarator, (10) confinement of Ohmic heated plasma in Sirius stellarator, (11) plasma behavior in toroidal traps, (12) electron confinement in closed systems, (13) magnetic configurations with width and minimum B, (14) blocked particle instability in toroidal systems, (15) plasma diffusion in NS stellarator, (16) equilibrium of toroidal hf discharge in a cell having a conducting shell with slots, (17) closed spatially-alternating magnetic configurations with minimum B, and (18) movement of transitory particles in a system with minimum B. (M.O.W.)

**15264** (KHFTI-69-43) BEHAVIOR OF OHMIC-HEATED PLASMA IN A LARGE-"LATITUDE" STELLARATOR "URAGAN". Vishnevetskii, V. N.; Volkov, E. D.; Dikii, A. G.; (and others) (Akademiya Nauk Ukrainskoe SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1969. 20p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The influence of "latitude" on the particle and energy loss rate was studied in the stellarator Uragan, using a closed magnetic trap. (R.V.J.)

**15265** (KHFTI-69-47) THERMOISOLATION AND CONFINEMENT OF PLASMA IN THE "SIRIUS" STELLARATOR. Burchenko, P. Ya.; Vasilenko, B. T.; Volkov, E. D.; Rudakov, V. A.; Tolok, V. T. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko Tekhnicheskii Institut). 1969. 8p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Previous studies of particle and energy confinement in closed magnetic traps showed that plasma losses exceeded, by several orders, the values assumed in classical diffusion and thermal conductivity. Theoretical data indicated that, in toroidal geometry, abnormally high rates of losses at small frequency of collisions can be determined, as well as Coulomb collisions. Particle and energy confinement for ohmic-heated plasma in the Sirius stellerator are reported here. The studies were confined, mainly to the basic processes responsible for the abnormally high transport coefficients of closed traps. (R.V.J.)

**15266** (MATT-734) PLASMA CONFINEMENT IN A LINEAR QUADRUPOLE. Palladino, R. W. (Princeton Univ., N. J. Plasma Physics Lab.). Feb 1970. Contract AT(30-1)-1238. 21p. Dep. CFSTI.

As a result of experiments with hot electron plasmas in the Princeton linear quadrupole device LM-1, several new methods have been derived for evaluating the lifetime of the whole plasma column. In particular, an effort has been made to hold all other important parameters constant and to study the dependence of total plasma lifetime on B (the magnetic field intensity) alone. The various methods seem to converge on plasma lifetimes which have a rather weak magnetic field dependence; in most cases not exceeding a $B^{\frac{1}{2}}$ law when the behavior is averaged up to 60 kA in each quadrupole conductor, the upper limit in LM-1 operations. Superimposed on the generally weak B dependence is a very pronounced periodic component (of unknown origin, but suggestive of resonance effects involving the whole plasma column). In view of the rather complex B dependence of the plasma containment it is a little misleading to speak of Bohm diffusion in LM-1, even allowing for the averaging along a flux line that must be done to determine an effective B. Unless the plasma temperature has an equally complex B dependence, even late in the decay when it has dropped well below 1 eV, it would appear that LM-1 containment times do not reflect the B/T relation so familiar from stellarator studies. (auth)

**15267** (NP-18118) EXCITATION OF SURFACE WAVE ON NON-HOMOGENEOUS PLASMA FLUX. STUDIES OF ANOMALOUS PLASMA HEATING UNDER THE INFLUENCE OF SURFACE WAVE FIELDS. Preprint No. 146. Sergeichev, K. F. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). 1969. 29p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Anomalous decay of inhomogeneous current in a collisionless plasma was studied, after injection into a circular waveguide excited on the $H_{01}$ type wave in the 10-cm area. It was observed that the disturbance of the boundary symmetry ($\vec{E} \cdot \nabla n = 0$) excited a surface dipole wave propagating along the boundary of a plasma of high negative dielectric penetrability, which was capable of increasing significantly the intensity of the ultrahigh-frequency field inside the plasma. It was also found that the surface wave in the case examined did not play an important part in plasma heating. The absence of anomalous heating processes in dense layers of injected current, in which the surface wave field is localized, was established. The relationship between plasma decay and the fast wave and its polarization in external fields was also found. (tr-auth)

**15268** BASEBALL SEAM MAGNET WITH VARIABLE MAGNETIC FIELD. Henning, Carl D.; Chargin, A. K. (to United States Atomic Energy Commission). U. S. Patent 3,491,318. 20 Jan 1970.

This patent relates to an electromagnet for confining high-temperature plasma comprised of more than one electrically independent, contiguous conductor coil formed in a configuration similar to the seam of a baseball. When the conductor coils are separately energized to different levels, they produce an asymmetrical, cusped magnetic field which increases in all directions away from the plasma confinement region, creating a magnetic well. The depth of the magnetic well is varied by changing the difference between the energizing levels of the conductor coils. (AEC)

**15269** TOROIDAL FUSION PLASMA WITH POWERFUL NEGATIVE BIAS. Stix, Thomas H. (Weizmann Inst. of Science, Rehovot, Israel). Phys. Rev. Lett.; 24: 135-8(26 Jan 1970).

Imposition of a powerful electrostatic bias allows a dense uniform-pressure plasma to be held in a static equilibrium in a toroidal closed-magnetic-line system. A small wall current of 3.5-MeV d–t alpha particles easily maintains the 6-MV/cm electric field necessary for controlled thermonuclear reaction conditions. As ions can be confined in an enormously deep energy well, the system lends itself also to production of highly stripped heavy nuclei. (auth)

**15270** VELOCITY DIFFUSION AND PLASMA CONFINEMENT IN MIRROR CONFIGURATIONS DUE TO ION CYCLOTRON INSTABILITIES. Chu, Mosi. Madison, Wis.; Univ. of Wisconsin (1969). 80p.

Thesis.

This investigation primarily concerns the diffusion rate of ions into the loss cone of open-ended containment devices and the estimate of the lifetime of plasma due to an ion cyclotron instability. For $T_{||_i} > T_{||_e}$, the ion distribution function in such devices is necessarily peaked around a nonzero perpendicular energy. Such a distribution invites instabilities. Velocity-diffusion equations are formulated quasi-linearly and the ion cyclotron instability is discussed through the principle of conservation of energy. This instability causes particles in the $\partial f^*/\partial v_\perp > 0$ regime to lose part of their perpendicular energy. Two important phenomena arise due to this velocity diffusion process. (a) These low-energy ions eventually escape from the magnetic trap. (b) The presence of these low-energy particles provides a very strong damping effect for the instability considered. As a result, an equilibrium is set up between velocity and coordinate space. An estimate of the plasma lifetime is derived from such an equilibrium configuration. This calculated lifetime is of the same order of magnitude as that observed in some experiments. (Diss. Abstr.)

**15271** X-RAY PRODUCTION IN LASER-HEATED PLASMAS. Bernstein, M. J.; Comisar, G. G. (Aerospace Corp., Los Angeles). J. Appl. Phys.; 41: 729-33(Feb 1970).

The efficiency of converting focused laser radiation into kilovolt x rays by means of a high-z planar plasma has been calculated. For electron temperatures of several keV, the rapid expansion of the plasma limits the effective absorption and reradiation times to a few tenths of a nanosecond. This short time limits the fractional degree of ionization to 30 to 60%, depending on the temperature, for heavy target ions such as gold, and in this case the predominant ions have ionization energies less than the electron temperature. For plasma temperatures of 3 up to 10 keV, the total radia-

tion output will range from 6 down to 2 times that of plasma bremsstrahlung alone. The conversion efficiency is relatively insensitive to the laser frequency and to the plasma temperature and amounts to 2 to 5%. Overall efficiency for a Nd-glass laser system turns out to be about $10^{-3}$. (auth)

**15272** HYDRODYNAMIC BEHAVIOR OF SOLID DEUTERIUM UNDER LASER HEATING. Fauquignon, C.; Floux, F. (CEA, Limeil-Brevannes, France). Phys. Fluids; 13: 386-91(Feb 1970).

A theoretical interpretation is suggested in order to explain the inward propagation of luminous fronts when a powerful laser beam is focused on solid deuterium ice. This model is based on the propagation of a shock wave followed by a laser-flux-driven deflagration. Calculations are made and compared with experimental results. (auth)

**15273** RIGID DRIFT MODEL OF HIGH-TEMPERATURE PLASMA CONTAINMENT. Morse, R. L.; Freidberg, J. P. (Los Alamos Scientific Lab., N. Mex.). Phys. Fluids; 13: 531-3(Feb 1970).

A model is proposed that appears to be consistent with certain recent high-temperature plasma heating and confinement experiments, whose behavior is not adequately described by magnetohydrodynamics. (auth)

**15274** COLLISIONAL DIFFUSION IN AN AXISYMMETRIC TORUS. Rutherford, P. H. (Princeton Univ., N. J.). Phys. Fluids; 13: 482-9(Feb 1970).

Collisional cross-field diffusion of plasma in a general axisymmetric torus is calculated using the Fokker–Planck collision term, and a variational principle is found for the diffusion coefficient. Anomalously large transport, as found by Galeev and Sagdeev, occurs where the effective collision frequency is of order or less than the "bounce" frequency of trapped particles. Only unlike-particle collisions contribute, and the ion and electron diffusion coefficients are equal and independent of any radial electric field; these conclusions differ somewhat from those of Galeev and Sagdeev. (auth)

**15275** COLLISIONAL DIFFUSION IN NONAXISYMMETRIC TOROIDAL SYSTEMS. Frieman, E. A. (Princeton Univ., N. J.). Phys. Fluids; 13: 490-6(Feb 1970).

Collisional cross field diffusion in nonaxisymmetric toruses with high shear has been found, but a region of minimum diffusion is shown to exist which might provide an attractive operating regime for future reactor considerations. The properties of this regime have been calculated and are discussed. (auth)

## Diagnostics

*Refer also to abstracts 14374, 14378, and 15180.*

**15276** (CTO-681) MEASUREMENT OF THE ION TEMPERATURE IN TOKAMAK-3 FROM THE DOPPLER BROADENING OF THE SPECTRAL LINES OF NEUTRAL HYDROGEN AND DEUTERIUM. Mirnov, S. V.; Semenov, I. B. Translated for Culham Lab., Abingdon, Eng., from Russian report. 10p. Dep. CFSTI (U. S. Sales Only).

The plasma ion temperature was measured by a modified method and compared to the optical method used for the determination of the ion temperature from the Doppler broadening of the spectral lines. The development is essentially that the necessary concentration of neutral atoms at the ion temperature is produced by charge exchange of deuterium plasma ions with a stream of hydrogen atoms injected by pulses during the discharge. The values for the ion temperatures are averaged over the column cross section; they lie in the range from 70 to 150 eV and, taking into account the assumed spatial distribution of the ion temperature, agree well with the results of ion temperature measurements from the spectrum of the neutral charge exchange atoms. (auth)

**15277** (NP-18115) MEASUREMENT OF THE ELECTRON TEMPERATURE OF A PLASMA USING A DIFFERENTIAL ANALYZER OF CHARGED PARTICLES ACCORDING TO ENERGY. Preprint 260. Alinovskii, N. I.; Nesterikhin, Yu. E.; Pogozin, A. I. (Akademiya Nauk SSSR, Novosibirsk. Institut Yadernoi Fiziki). 1968. 31p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The design of a differential analyzer of electrons according to energy is described, and the basis of the method of measuring electron temperature in a plasma through the use of this device is given. The possibility of a distortion introduced by the measuring process into the energy spectrum of the electrons is analyzed. The electron temperature $T_e$ of a plasmoid generated by a conical induction source was measured to show that the method described yields correct information despite its contact nature. The maximum values of $T_e$ achieved were of the order of 150 to 250 eV. The slight preionization does not make any noticeable increase in electron temperature but only raises the density and the total number of particles in the plasmoid. The controlling magnetic field produces mainly an increase in the directed energy of the plasmoid. (JPRS)

**15278** TIME-DEPENDENT THEORY OF AN ELECTROSTATIC PROBE. Giles, Eunice J. (Univ. of Western Australia, Perth); Klotz, A. H. Proc. Roy. Soc. (London), Ser. A; 314: 341-61(13 Jan 1970).

The electrostatic probe technique has been used extensively in experimental investigations of plasma properties. There exists a well developed theory of stationary systems but little work seems to have been done on the cases where time dependence is not negligible. In the present paper, a technique is described which is suitable for situations in which time-variation is significant. A time-dependent probe theory is set up, so that measurements made using the method can be related to the internal properties of the plasma. The particular problem considered is that of a flame front traversing a narrow passage. Two cases are considered: (i) the passage is of rectangular cross section, with pairs of electrostatic probes set in opposite walls; (ii) the passage is of annular cross section, with sections of the inner and outer walls being used as probes. As the flame front passes them, the probes, in both cases, collect from the ionized gas a current which varies in time. The flame gas is considered to be a three-component plasma, and a set of time-dependent partial differential equations governing the collection of charged particles is derived. These are linearized and then solved using the Laplace transformation method. This gives a solution of the problem in the form of a generalized Fourier series. Approximations are made to the series solution to permit the calculation of the free stream ion density from the electric charge collected by the probe as the flame front sweeps past it. The value found in this way compares favorably with empirical results. (auth) (UK)

**15279** USE OF COOLED PROBES FOR PLASMA MEASUREMENTS. Sahni, O. (Rensselaer Polytechnic Inst., Troy, N. Y.). J. Phys., D (London); 3: 176-83(Feb 1970).

The effect on plasma measurements at high pressure of the thermal sheaths in front of plane cooled probes is discussed both for stationary and flowing plasmas. In stationary plasmas, the measured electron energy would be dependent on the probe temperature owing to the losses in the thermal sheath. A critical review of some of the earlier experimental work with cooled probes shows the limitations of the stationary analysis since most high-pressure and high-temperature plasmas are flowing plasmas. It is suggested that in flowing plasmas the cooled probes give reliable results for electron energy owing to the dependence of the thermal boundary layer thickness on the distance from the leading edge of the probe along the flow direction. An order-of-magnitude estimation is made for the thermal layer thickness of a low-gas-flow argon arc at atmospheric pressure. The normal use of highly negative cooled-probe data for charge-density measurements is reasonably accurate both for stationary plasmas and for flowing plasmas where the probe surface is aligned along the flow direction. However, in flame and alkali-seeded inert gas plasmas, the probe current would become dependent on the cooled probe temperature owing to the influence on the thermal ionization process in the vicinity of the probe. (auth) (UK)

**15280** ELEKTRICHESKII ZOND V PLAZME. (Electric Probe in Plasma). Kozlov, O. V. Moscow; Atomizdat (1969). 292p.

Theoretical and experimental data on probe measurements in plasma and construction of probe equipment are discussed. The concepts and equations, particle motion in a central-symmetric field, probe characteristics, electric probes in isothermal and nonisothermal plasmas, and double and multiple probes are described in the first 5 chapters. The last 5 chapters deal with probe measurements of moving plasma, electric probes in magnetic fields and high-pressure gases, and other variations of probe methods and techniques. 209 references. (R.V.J.)

**15281** MICROWAVE PLASMA DENSITY MEASURING SYSTEM WITH MICROSECOND RESPONSE TIME. Burns, Stanley G.; Beyer, James B. (Univ. of Wisconsin, Madison). Contract AT-(11-1)-1233. Rev. Sci. Instrum.; 41: 33-6(Jan 1970).

Based on the STALO (acronym for STAbilization of Local Oscillator) system wherein an external high Q cavity is used to frequency stabilize a reflex klystron, a technique was developed using a microwave Fabry–Perot resonator (MFPR) operating at 35 GHz for performing time-varying plasma diagnostics over a two- to three-order-of-magnitude range centered at $5 \times 10^9$ electrons/cm$^3$. Experimental results are given for 2-MHz density variations in a 125-$\mu$ He rf-induced discharge. The frequency response is an order of magnitude faster than an external feedback control sys-

tem (also described) which utilizes the MFPR. Calibration techniques as well as the underlying theory are also given. (auth)

**15282** ERRORS IN MEASURING CONCENTRATION OF CHARGED PARTICLES BY SPECTRAL LINES IN INHOMOGENEOUS PLASMA SOURCES. Grechikhin, L. I.; Voinov, B. B. (Minsk Rocket Engineering School of Antiballistic Defence). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 10, 95-8(1969). (In Russian).

Charged-particle concentrations determined, with the order of error of 10 to 15%, by spectral line broadening at various Stark effect constants in inhomogeneous plasma were related to the zones of maximum luminosity of the spectral line centers. Recordings of the contour in which the spectral luminosity of the line centers exceeded considerably, the spectral luminosity at the edges were related to the center zones of the inhomogeneous source. However, in the case in which the line center luminosity did not exceed by much the luminosity at the edges, the recordings were related to the periphery of the nonhomogeneous source. (tr-auth)

**15283** RF METHOD FOR DETERMINING THE COMPLEX CONDUCTIVITY OF A PLASMA BY EXTERNAL PROBES. Maiti, J. N.; Basu, J. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 207-10(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

In this method the probes consisting of a pair of coils placed around the plasma tube and separated from each other by a short distance act as the primary and secondary coils of a transformer. An impedance method for determining the complex conductivity, which involves the measurement of the impedance of a coil placed around the plasma tube, is also discussed. (M.O.W.)

**15284** RF MEASUREMENTS OF THE SHEATH THICKNESS IN A PLASMA. Sen, C.; Basu, J. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 211-15(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Results obtained by an rf impedance method are reported, pertaining to the sheath of a plane probe immersed in a glow-discharge plasma and biased with a dc voltage. (M.O.W.)

**15285** ELECTRICAL AND THERMAL CONDUCTIVITY OF HYDROGEN UP TO 27,000°K. Plantikow, U.; Steinberger, S. (Technische Hochschule, Munich). Z. Phys.; 231: 109-18 (1970). (In German).

For determination of the heat flux potential S and of the electrical and thermal conductivity $\sigma$ and $\kappa$ as functions of temperature, the radial distributions of S, $\sigma$, and T are needed. These distributions were evaluated from measurements made directly on a hydrogen plasma in a cascade arc chamber of high power load at a pressure of 1 atm. By elimination of the radius as variable, the electrical conductivity $\sigma$ and the heat flux potential S are determined as functions of temperature. Theoretical and experimental results of the electrical conductivity agree very well. The absolute values of the measured and theoretical $\kappa$ curve differ by a factor of about two at temperatures above 5,000°K. This deviation could not be explained. Together with other data, there are now measurements of the electrical and thermal conductivity of hydrogen at a pressure of 1 atm up to 27,000°K corresponding to a degree of ionization of 98%. (D.L.C.)

**15286** DETERMINATION OF THE DENSITIES AND TEMPERATURES OF TWO LOW-ENERGY ELECTRON GROUPS IN A HOLLOW-CATHODE DISCHARGE. Cellarius, C. J.; Dicks, L. A.; Turner, R. (National Physical Research Lab., Pretoria). Z. Phys.; 231: 119-27(1970).

A new method of Langmuir probe analysis for non-Maxwellian plasmas is proposed. The method consists of computer fitting a mathematical function to the normal probe voltage-current characteristic, assuming two groups of electrons, each with a Maxwellian distribution. The advantages of the method are that both the temperatures and the densities of the two groups may be determined and that the electron energy distribution function is a tractable mathematical function. The two groups are proven to be very nearly Maxwellian in the pressure range of 1.8 to 3.8 torr helium and the results are in excellent qualitative agreement with results obtained spectroscopically by other authors. (auth)

**15287** CONSTRICTED POSITIVE COLUMN IN NEON. Mouwen, C. A. M.; Claassens, J. M. M. (Univ. of Tech., Eindhoven, Netherlands). Phys. Lett.; 31A: 123-4(9 Feb 1970).

The radial gas temperature distribution in a constricted positive column in neon was measured. The shape of this distribution function can be understood by assuming a thermal constriction model. (auth)

**15288** ELECTRON BEAM MEASUREMENT OF ION ACOUSTIC WAVE PROPAGATION. Goldan, Paul D. (Environmental Science Services Administration, Boulder, Colo.); Leavens, William M. Phys. Fluids; 13: 433-9(Feb 1970).

Ion-acoustic wave propagation, near the sheath developed at a plasma/wall boundary, was investigated in a low-pressure ($\sim 5 \times 10^{-4}$ torr) argon plasma by an electron beam probing technique. Waves propagating into the plasma were found to have velocities $\sim 2 \times 10^5$ cm/sec, increasing with distance from the wall. The results are consistent with an analysis in terms of an ion free-fall model of the sheath. The model also makes plausible the observed zero reflection coefficient for small ion acoustic disturbances at the plasma boundary. (auth)

**15289** ON THE POSSIBILITY OF MEASURING MAGNETIC FIELDS BY SCATTERED LIGHT. Lehner, G.; Pohl, F. (Institut fuer Plasmaphysik, Garching, Ger.). Z. Phys.; 232: 405-14(1970).

In the case of uncorrelated electrons (i.e., $\alpha \ll 1$) the electron spectrum is modulated with the electron gyration frequency if a certain condition is fulfilled. The essential parameters are discussed and some spectra are computed numerically. (auth)

**15290** INVESTIGATION OF ERRORS IN MEASURING MAGNETIC FIELDS IN HIGH-TEMPERATURE PLASMA DISCHARGES. Schreiber, Paul W. (Aerospace Research Labs., Wright-Patterson AFB, Ohio); Schumaker, Karl H.; Benedetto, Kenneth R. AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1693-8(Sep 1969).

The source of errors in using magnetic probes in high-temperature plasmas and the correction or elimination of these errors are investigated. The particular sources of error considered are (1) errors caused by the finite size of the element which yields an average rather than a point value, (2) errors in the calibration caused by the heating of the probe element, (3) errors in the determination of probe position, and (4) errors associated with the disturbance of the current density resulting from the insertion of the probe into the plasma. The magnitude of these errors and the compensation methods are discussed. (auth)

## *Kinetics (General)*

*Refer also to abstract 15634.*

**15291** TEMPERATURE AND FLOW FIELDS IN A WALL-STABILIZED MAGNETICALLY DEFLECTED ARC. Sauter, Karl (Technische Hochschule, Munich). Z. Naturforsch.; 24a: 1694-1706(Nov 1969). (In German).

The influence of the Lorentz forces—caused by a stationary traverse uniform magnetic field—and the thereby-induced flow field on a wall-stabilized electric arc in argon was experimentally investigated. The unsymmetrical temperature fields in the arc discharge cross section for different values of arc current and magnetic field were determined by measuring the continuum radiation absolutely. The material functions of argon are taken from recently published literature; the specific radiation u(T) is evaluated from the measurements. The convective term of the energy equation provides the component of the flow velocity parallel to grad T; herefrom, together with the continuity equation, the flow field is calculated. The evaluation of the momentum equation shows that, within the main part of the arc cross section, the Lorentz force is essentially compensated by a pressure gradient and not by inertial or viscous forces. The consistency of the results verifies the measurements, the applied material functions and the evaluation procedures. (auth)

**15292** HARMONIC GENERATION IN NONLINEAR BEAM-PLASMA SYSTEMS. Konrad, Gerhard Thies. Ann Arbor, Mich.; Univ. of Michigan (1969). 289p.

Thesis.

The saturation characteristics of beam-plasma devices were investigated theoretically and experimentally. The geometry treated in this study consists of a cylindrical plasma column which serves as a slow-wave circuit along which electromagnetic energy can propagate. A cylindrical electron stream is assumed to be concentric with the plasma column. Amplification of an rf signal takes place when a fraction of the kinetic energy of the stream electrons is converted into rf wave energy. An experimental test vehicle is described that permits correlation of the theoretically calculated results with those obtainable from an actual beam-plasma interaction. A xenon plasma column 10.5-cm long is generated by either a hot-cathode Penning discharge or by ionization due to the beam electrons passing through the xenon gas. Values of electronic gain as high as 35 dB in the vicinity of 2.0 GHz are obtained experimentally by the latter scheme. Har-

monic components through the fifth are observed with the second harmonic being only 5 dB below the fundamental under certain conditions. When collision effects are taken into account in the theoretical calculations, it is shown that the agreement with the experimentally observed values is quite good for the cases that can be compared. Coupling of rf energy into and out of the beam–plasma device is considered in detail theoretically and experimentally. Short sections of a slow-wave structure outside of the plasma region are used in the device under test for much of the experimental work. Another coupling scheme making use of quasi-optical techniques is a set of elliptic cavity couplers. These are found to yield a coupling loss of only 10 to 15 dB per coupler over a frequency range of slightly greater than 20% in the low S-band frequency region. This coupling approach is much less lossy than most other methods employed previously. Efforts to use these couplers for rf amplification measurements are shown to be unsuccessful due to cathode poisoning at the higher gas pressures required. (Diss. Abstr.)

**15293** COMPARISON OF MEASURED AND PREDICTED CONDITIONS BEHIND A REFLECTED SHOCK. Bengtson, Roger D.; Miller, Myron H.; Koopman, David W.; Wilkerson, T. D. (Univ. of Maryland, College Park). Phys. Fluids; 13: 372-7(Feb 1970).

Measured thermodynamic conditions behind reflected shocks in a gas-driven diaphragm shock tube are compared to Rankine–Hugoniot predictions. Pressures of the shock-heated neon, which contained small concentrations of spectroscopic additives, were measured by quartz transducers. Temperatures (9000 to 13,000°K) were simultaneously measured spectroscopically by line reversal and absolute emission techniques, while electron densities were measured by the broadening of the Balmer line $H_\beta$. The temperature has been measured to an accuracy of ±1.5%, while electron densities have been determined with an accuracy of ±10%. Pressure measurements attained accuracies of ±5%. The consistency of the data indicates that a homogeneous local thermodynamic equilibrium model is an adequate description of the shock-heated gas. The state measurements, compared with the real gas Rankine–Hugoniot predictions, show significant departures. Predicted temperatures are typically 3% ± 10% higher than those measured. The predicted electron density is as much as ±30% in error, and the predicted pressures are systematically lower than those measured by approximately 7% ± 15%. (auth)

**15294** KINETIC PROCESSES IN GASES AND PLASMAS. Hochstim, A. R. (ed.). A Volume in the Reentry Physics Series. New York; Academic Press Inc. (1969). 469p. $22.50.

Separate abstracts were prepared for four of the individual sections. (M.O.W.)

*For abstracts of individual sections see: 15131 and 15331–15333.*

## Kinetics (Experimental)

**15295** (CONF-680520–, pp 316-25) PULSE DURATION EFFECT ON PLASMA RESISTIVITY. Creedon, John E.; Schneider, Sol (Army Electronics Command, Fort Monmouth, N. J. Electronic Components Lab.).

At the Ninth Modulator Symposium the resistivity of high-current discharges in hydrogen was discussed. At that time, the pulse-width dependence had not been studied, and it was believed that the resistivity was essentially independent of pulse width until thermal conduction and radiation heating of the wall introduced impurities. Further measurements were made on 3-inch-diameter tubes with electrode spacings ranging from 2 to 20 inches. The pulse duration used was 56 μsec as compared to 28 μsec for the previous study. The resistivity was calculated from the tube drop vs current measurements. A comparison was made with the resistivities predicted from electron density and temperature measurements obtained from Stark broadening and line-intensity ratio techniques. It was determined that a gas temperature correction had to be made for the pressure-dependent term of the predicted resistivity. The temperature correction was directly proportional to the power dissipated in the gas discharge. It was concluded that, in long pulses, gas heating effects can increase the plasma resistivity significantly. Results obtained at 15 and 22 kA and pressures of 0.5, 1.0, and 5.0 torr are presented. (auth)

**15296** (KHFTI-69-30) COLLECTIVE INTERACTIONS AND PLASMA HEATING IN HIGH-CURRENT GAS DISCHARGE. Suprunenko, V. A.; Sukhomlin, E. A.; Tolok, V. T. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1969. 15p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Processes inducing kinetic instabilities and heating of dense plasma placed in a strong electric field were studied. Data obtained showed that effective heating of electron and ion plasma components took place in a high-current gas discharge during the development of high-frequency instabilities accompanied by anomalous plasma resistance and intense microwave emission. Results are discussed and the possibility of finding the mechanism inducing the instabilities was analyzed. (tr-auth)

**15297** (KHFTI-69-31) COLLECTIVE INTERACTIONS IN LOW-DENSITY PLASMA WITH HIGH-CURRENT GAS DISCHARGE. Masud, M. M. M.; Maznichenko, M. E.; Reva, N. I.; Suprunenko, V. A.; Sukhomlin, E. A.; Ternopol, A. M.; Tyupa, V. I. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1969. 8p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Experimental studies were made of instabilities appearing in electrode discharge during its initial stages, when the degree of ionization of the working gas was small and the plasma density was low. It is shown that the collective process is similar to the interactions during external electron beam injection into plasma and differs considerably from the processes developing in dense highly ionized plasma in high electric fields. Data obtained indicate that the collective processes can substantially influence the mechanism of breakdown of neutral gas. (tr-auth)

**15298** (KHFTI-69-32) COLLECTIVE INTERACTIONS IN A FAST THETATRON. El'Khalafavi, T. A.; Suprunenko, V. A.; Ternopol, A. M.; Khafiz, L.; Yuzef, A. M.; Burgam, A. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1969. 18p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Studies of collective processes in a discharge theta-pinch plasma showed that the kinetic instability in plasma is excited at the expense of anisotropy of electron energy distribution appearing during electron acceleration by the azimuthal electric field of the discharge. A nonadiabatic induction acceleration without producing a steady orbit proved to be the highly probable mechanism of electron acceleration. An epithermal microwave plasma emission consisting of a series of cyclotron harmonics, distributed below the plasma frequency was observed. At high amplitudes of these oscillations the plasma electron energy slowly became isotropic. It was found that the time of balancing of anisotropy was about 0.2 μsec, and magnitude of electron energies acquired and the region of their acceleration are in good agreement with the calculated data. The intensity of microwave emission from plasma increased by the order of two, in the case in which the frequency of higher cyclotron harmonics coincided with plasma frequencies. The easiest excitation was observed with harmonics of numbers 2, 4, and 8, without radiation at the fundamental frequency. The maximum radiation was found in the direction forming a sharp angle with the direction of the magnetic field. The radiation was polarized so that the vector of the electric field waves were perpendicular to the external magnetic field. (tr-auth)

**15299** MEASURING THE ELECTROTHERMAL EFFICIENCY OF A 50-Hz PLASMA TORCH. Roots, William K. (Univ. of Windsor, Canada); Kadhim, Mazin A. H. IEEE (Inst. Elec. Electron. Eng.), Trans. Instrum. Meas.; IM-18: 150-6(Sep 1969).

A plasma torch of the nontransferred type is described in which the power supply was main frequency ac (50 Hz). A detailed view of this torch is shown. The arc is struck between the outer (annular) and inner (column) electrodes, and rotated at high speed (≈ 100,000 R/min) by a transverse magnetic field (≤ 0.5 tesla) produced by the field coil. Then the gas (air) passes through the annular gap (flow rates ≤ 50 g/s) to produce the plasma jet. The maximum electrical rating of this torch was 100 kW. Measurement of electrothermal efficiency in this plasma torch is described. It was found that the best method of measuring arc input power was an electronic system involving multiplication and integration although thermal wattmeters could be used with a slight loss of accuracy. A self-jacketed parallel-flow calorimeter was found best for measuring the heat content of the torch output. The flow-dependent thermal efficiency of this torch was found to exceed 60%. For established designs of torch the electrode losses can be used to establish the input power to the arc, and thus eliminate the need for an electrical measurement. (BBB)

**15300** STUDY OF BEAM–PLASMA DISCHARGE. I. WAVE CHARACTERISTICS. Yatsui, Kiyoshi; Yamamoto, Yukio; Saeki, Koichi; Hasegawa, Akira (Osaka Univ.). J. Phys. Soc. Jap.; 28: 489-95(Feb 1970).

Strongly ionized, hot electron plasmas were produced by unmodulated, high-power electron beam interactions with plasmas, of which properties were investigated both experimentally and theoretically, especially on characteristics of waves excited: When the plasma is considerably quiescent in a region of small beam power, low-frequency ion plasma wave (~ several MHz) is found to be excited by a coupling with slow cyclotron waves of the electron beam. Besides this, weak excitation of high-frequency

oscillations (~1 GHz) occurs in this region presumably due to a coupling between electron cyclotron waves of the plasma and slow cyclotron waves of the beam. In a turbulent plasma state above a certain critical beam power, plasma hybrid wave interactions with beam slow waves become essential for the plasma instability exciting powerful high-frequency oscillations (~ several GHz), which seems to lead to production of strongly ionized plasmas. (auth)

**15301** THETA-PINCH PLASMA GUN STUDIES. Turner, R. (Johns Hopkins Univ., Silver Spring, Md.). APL (Appl. Phys. Lab.) Tech. Dig.; 8: 2-13(May-Jun 1969).

A theta-pinch plasma gun developed to study the interpretation of a high-temperature, high-density plasma with various magnetic fields is described. The plasma is produced between two mirror-shaped pinch coils, each having an independent capacitor bank source. In the normal operating sequence, gas is pulsed into the region between the coils, and pre-ionized by a low-energy 3-MHz discharge through the coils. It is compressed, heated, and ejected by the discharge of the main capacitors; the two fast banks are discharged simultaneously, while the discharge of the slower bank is adjusted to maximize the energy of the plasma output. The gun produces a doughnut-shaped puff of hydrogen plasma having an average density of 1 to $2 \times 10^{15}$ particles/cm$^3$, a temperature of 350,000°K, and a directed velocity of $2 \times 10^7$ cm/sec. A variety of techniques was used to study the plasma including a specially developed fast far-ir interferometer. A significant amount of the directed plasma energy can be converted into more useful transverse (random) energy by reflecting the plasma from a magnetic barrier. (BBB)

**15302** DIFFUSION OF CHARGED PARTICLES IN A PIG DISCHARGE. Bose, D. K.; Chatterjee, A. K.; Sen Gupta, S. N. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 198-201(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The radial density distribution of plasma ions was determined by a pair of floating electrical probes. Density distribution curves are given for five different magnetic fields from 300 to 1400 gauss. The gas was residual air at $10^{-3}$ mm Hg. (M.O.W.)

**15303** ANALYSIS OF CONTINUUM RADIATION FROM NITROGEN PLASMAS. Asinovskii, E. I.; Kirillin, A. V.; Kobzev, G. A. (Inst. for High Temperatures, Moscow). J. Quant. Spectrosc. Radiative Transfer; 10: 143-64(Mar 1970). (In Russian).

Continuum radiation of nitrogen plasmas from 2500 to 20,000 Å, at atmospheric pressures and at temperatures ranging from 10,000 to 17,000°K, has been studied experimentally and theoretically. It is shown (from an analysis of the literature and of our experiments) that the observed radiation intensities for air and nitrogen plasma under our experimental conditions are significantly higher than theoretical predictions. In the theory, account is taken of molecular radiation, atomic lines, electron–ion photo-recombination, electron–ion and electron–neutral bremsstrahlung. The magnitudes and the causes of the observed discrepancies are investigated. The electron–ion continuum calculation technique is re-examined and the shifts of the photoionization edges are taken from experiment. The excess radiation is explained as resulting from photoattachment of the negative nitrogen ion. The required photodetachment cross section is derived from experimental data. This value is compared with theoretical and experimental results obtained by other authors. Qualitative differences between experimental data at 10 to 100 and 1 atm are discussed. Other possibilities to account for the observed excess radiation are also considered. (auth) (UK)

**15304** INFLUENCE OF PLASMA FREQUENCY ON THE LIGHT EMITTED BY AN EXPLODING IONIZED GASEOUS FILAMENT. Skowronek, M.; Rous, J.; Goldstein, A.; Cabannes, F. (Centre National de la Recherche Scientifique, Bellevue, France). Phys. Fluids; 13: 378-85(Feb 1970).

A very dense and easily reproducible plasma was generated by the explosion of a thin preionized gaseous column. The optical thickness of the discharge was measured by means of a laser and the absorption coefficient was found to be higher than 18 cm$^{-1}$. The spectral brightness of the discharge is measured from wavelengths 0.2 $\mu$ to 4.8 $\mu$. The instantaneous spectral distribution shows an abrupt drop in the near infrared at 1 $\mu$. This is interpreted as being due to the plasma frequency with a corresponding electron density of $(1 \pm 0.2) \times 10^{21}$ cm$^{-3}$. The complex index and the emissivity of the plasma are calculated and give a spectral repartition in good agreement with the measured one. Between 0.5 $\mu$sec and 1 $\mu$sec after the breakdown, the discharge column radiates as a blackbody at 44,000°K over a large spectral region. The free–free transitions, mainly in the infrared, can explain the radiation observed. The light is found to originate from a shell $2 \times 10^{-3}$ cm thick, in agreement with the structure found for such sparks. (auth)

**15305** GROWTH AND DAMPING OF WAVE–PARTICLE INTERACTIONS IN COUNTERSTREAMING ELECTRON BEAMS. Murakami, M.; Lidsky, L. M. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-3980. Phys. Rev. Lett.; 24: 297-300(16 Feb 1970).

Experimental observations were made of wave–particle interactions in counter-penetrating electron beams in a static magnetic field. A new technique is used to measure the electron-distribution function at every stage of wave growth, saturation, and decay. The particular instability discussed here occurs at one half the cyclotron frequency and has a density threshold for onset. As the wave grows, trapping of resonant particles in the wave-potential troughs becomes significant and the velocity distribution is appreciably broadened. Finally, "finite-temperature" stabilization prevails and the wave decays. The experimentally observed resonance width is in agreement with the predictions of strong turbulence theory. (auth)

**15306** EFFECTS OF PLASMA FLOW ON ELECTROSTATIC DISTURBANCES IN A Q MACHINE. Korn, P.; Marshall, T. C.; Schlesinger, S. P. (Columbia Univ., New York). Phys. Fluids; 13: 517-26(Feb 1970).

The evolution of a large discontinuity in density in a single-ended Q machine was found to be adequately described by a free-streaming model of the ions modified by a density gradient electric field due to a finite electron temperature. As the electron temperature is increased through microwave heating at cyclotron resonance, the profile of the discontinuity is found to broaden spatially as predicted by the theoretical model. The plasma ion drift velocity along the magnetic field can be measured from the motion of the discontinuity and is found to be in close agreement with the drift velocity measured from the propagation of small-amplitude ion-acoustic waves. An estimate of the ion thermal velocity parallel to the magnetic field can also be obtained from the broadening of the discontinuity profile. The ion drift velocity exhibits systematic variation with changes in oven and ionizer temperatures which is attributable to the electron–ion balance in the region surrounding the hot ionizer. (auth)

## Kinetics (Theoretical)

*Refer also to abstract 15185.*

**15307** (AD-696243) A COMPUTER PROGRAM FOR THE CALCULATION OF THE ELECTRON TRANSPORT COEFFICIENTS. Mitchner, M. (Stanford Univ., Calif. Plasma Gasdynamics Lab.). Aug 1969. Contract F33615-69-C-1171. 38p. (AFAPL-TR-69-63; SU-IPR-280). CFSTI.

A general computer program is described for the calculation of the electron transport coefficients in a partially ionized collision-dominated gas with or without a magnetic field. Included are the electrical conductivity, thermal conductivity, thermal diffusion coefficient, and the Hall parameter. Complete instructions are provided for the use of the program. (auth) (USGRDR)

**15308** (NP-18119) HYDRODYNAMICS OF PLASMA IN A STRONG HIGH-FREQUENCY FIELD. Preprint No. 174. Gorbunov, L. M. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). 1969. 80p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Equations obtained for plasma hydrodynamics in strong hf fields and the cases in which these equations can be simplified are discussed in the first part of this review. Properties of small perturbations in plasma with propagating strong electromagnetic waves of assigned amplitude (the inflated wave) and, in particular, studies of paramagnetic resonance and so-called dissipative instabilities are covered in the second part. The problems on plasma equilibrium and plasma dynamics in high-frequency fields are discussed in the third and fourth parts of the review. 140 references. (R.V.J.)

**15309** SURFACE-WAVE EXPERIMENT ON INHOMOGENEOUS PLASMA. Ilic, D. B.; Anicin, B. A. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Int. J. Electron.; 28: 41-50(Jan 1970).

The phase and attenuation characteristics of an axially symmetric surface wave on an inhomogeneous plasma column in mercury vapor have been determined using an interferometer setup. With signal frequencies between 100 and 300 MHz, mercury vapor pressures between 0.5 and 1.2 m torr the attenuation coefficient varies between 0.75 and 5.4 N/m. The data are compared to a cold plasma theory which takes into account the effect of profile and the loss in the glass surrounding the plasma. The resulting effec-

tive electron–atom collision frequency varies between $3 \times 10^7$ and $1.2 \times 10^8$ $sec^{-1}$. As the variation with vapor pressure and discharge current is not of the type expected by cold plasma theory, the conclusion is drawn that damping mechanisms other than collisions are present. (auth) (UK)

**15310** QUANTUM THEORY OF FINITE dc RESISTIVITY OF PLASMA. Nandedkar, D. P.; Bhagavat, G. K. (Indian Inst. of Tech., Bombay). Int. J. Electron.; 28: 51-77(Jan 1970).

Previously a theory of rf conductivity of plasma was discussed in which the absorbed rf energy, in the region of backward waves, gave rise to noise in general (Nandedkar and Bhagavat (1969)). A theory of finite dc conductivity of plasma is now developed in which, during the process of electron collisions with molecules in the plasma when dc energy is absorbed, the distribution of electrons is altered. Rearrangement of the electrons with respect to different states of the distribution produces "quantum jumps" to give rise to photons that govern noise distribution in accordance with the temperature of the new distribution of electrons obtained. (auth) (UK)

**15311** ELECTRON DENSITY AND TEMPERATURE ELEVATION OF A POTASSIUM-SEEDED PLASMA BY LASER RESONANCE PUMPING. Measures, R. M. (Univ. of Toronto). J. Quant. Spectrosc. Radiative Transfer; 10: 107-25(Feb 1970).

The feasibility of enhancing both the electron density and temperature of an alkali-seeded plasma by pumping the resonance lines of the alkali atoms with a suitably tuned laser of moderate power was studied. Calculations for a potassium-seeded plasma showed that it should be possible to elevate the electron temperature and density from 2000°K and $10^{12}$ $cm^{-3}$ to 3600°K and $2.5 \times 10^{14}$ $cm^{-3}$, respectively, in about 2.5 $\mu$sec with a power dissipation of less than 160 W $cm^{-3}$ in the form of laser radiation and with an efficiency of better than 90%. It is clear that this technique has considerable potential as a means of igniting a low-temperature potassium-seeded plasma to the point where Joule heating may be able to sustain the plasma condition. Moreover, this concept has two important advantages over the conventional method of applying an electric field in an attempt to produce nonequilibrium conditions. In the first instance, the electron density and temperature are uniformly enhanced across the duct of any MHD device, and in the second, it should not induce any instabilities in the presence of a magnetic field. (auth) (UK)

**15312** RELATIVISTIC BOLTZMANN EQUATION FOR PLASMAS. Akama, Hachiro (Kyushu Univ., Fukuoka). J. Phys. Soc. Jap.; 28: 478-88(Feb 1970).

A relativistically invariant formulation of the Boltzmann equation with collision terms is established on the basis of elastic binary collisions. The collision cross sections to be used are those obtained in relativistic quantum mechanics. The theory is applied to plasmas of Boltzmann statistics. The Coulomb divergence arises in the same way as in the nonrelativistic case, and the cutting-off that neglects the effects of distant collisions is indispensable. The covariant Landau equation is obtained for the electron and electron–proton plasmas. The impulse approximation is discussed in connection with the Coulomb divergence involved in the derivation of the Landau equation. (auth)

**15313** OSCILLATIONS OF A RELATIVISTIC ELECTRON PLASMA IN AN EXTERNAL MAGNETIC FIELD. Roth, G. (Roland Eoetvoes Univ., Budapest). Acta Phys. Acad. Sci. Hung.; 27: 309-22(1969).

A relativistic treatment of plasma oscillations is presented. The calculations are carried out for the so-called low-$\beta$ plasma, where the pressure is negligible as compared to the magnetic energy density. The covariant dispersion relations are derived and their meaning is compared to that of the classical ones. (auth)

**15314** PERTURBATION APPROACH TO NONLINEAR VLASOV EQUATION. Kawakami, Ichiro (Nihon Univ., Tokyo). J. Phys. Soc. Jap.; 28: 505-14(Feb 1970).

A new perturbation theory based on a canonical transformation for solving the Vlasov equation is developed. The theory is designed to cope with time secularities. The method is based on the transformation of original system to the new system where the particle is in free motion, that is, the transformed Vlasov equation is of free streaming. Practical calculation is systematic but restricted to the second order approximation in the expansion parameter (wave potential energy/particle kinetic energy). The result is used to obtain Fokker–Planck-type equation, and a velocity space diffusion coefficient is obtained. (auth)

**15315** UTILIZATION OF SIMPLE FUNCTIONS IN THE APPROXIMATION OF MAXWELL DISTRIBUTIONS. Feix, Marc; Rooy, Bruno (Centre National de la Recherche Scientifique, Saint-Maur-des-Fosses, France). Compt. Rend., Ser. B; 270: 148-50(12 Jan 1970). (In French).

In some problems of electrodynamics in hot isotropic plasmas, it is mathematically difficult to use Maxwell distributions. The approximation by Cauchy distributions of high order makes the calculations easier and leads to a correct field description for finite distances. (France)

**15316** ELECTRONS IN A COLLISIONLESS PLASMA FLOW AROUND A CONDUCTING BODY. Fournier, Gerard (Office National d'Etudes et de Recherches Aerospatiales, Chatillon-Sous-Bagneux, France). Compt. Rend., Ser. B; 270: 50-3 (5 Jan 1970). (In French).

Electron density around a cylindrical body and current density on it are numerically calculated. (France)

**15317** LAMINAR PLASMA JET OF ARGON AND NEON OUTSIDE EQUILIBRIUM. Czernichowski, Albin (Polytechnical School, Wroclaw); Chapelle, Joseph; Cabannes, Francois. Compt. Rend., Ser. B; 270: 54-7(5 Jan 1970). (In French).

Distributions of electron densities, excited state densities, and neutral-particle temperatures were studied. The relative populations of all excited levels, as well as the electron densities, correspond to the equilibrium at the temperature of neutral particles (about 4,000°K) but the absolute values of these populations are very high (and correspond to a temperature of 10,000°K). To explain these results, one must admit a low recombination coefficient ($10^{-12}$ $cm^3 \cdot sec^{-1}$) or take into account the metastable states. (France)

**15318** INVESTIGATIONS OF A SHEET MODEL FOR A BOUNDED PLASMA WITH MAGNETIC FIELD AND RADIATION. Langdon, Allan Bruce. Princeton, N. J.; Princeton Univ. (1969). 75p.

Thesis.

A number of extensions are made to the usual one-dimensional sheet model for a plasma. The sheets, which lie in the y–z plane, are allowed to move in the x–y directions, passing freely through one another. The motion in the x direction produces the usual electrostatic field $E_x$, while the motion in the y direction produces retarded radiation fields $E_y$ and $B_z$ which are included in the calculation. A static external magnetic field in the z direction is included, and the smoothed-out stationary neutralizing background charge density varies with x. Physical properties of this model are discussed. Expressions are derived for the synchrotron radiation from a gyrating sheet and the thermal radiation on the discrete space–time grid (used in the computer code). Dispersion properties of electromagnetic waves in the hot magnetized slab are discussed. Some peculiar aspects of the retarded radiation fields in one dimension are reconciled with the retarded fields from an extended body in three dimensions. The coupling of oscillations of the bounded slab to the field outside is discussed. A computer code has been written to follow the model in time from some initial state. Measurements are presented and discussed of sheet drag and of the spectrum of emitted radiation when the model is near equilibrium. (Diss. Abstr.)

**15319** RADIATION IN AN ANISOTROPIC ELECTRON PLASMA POLARIZED UNDER A STRONG MAGNETIC FIELD. Khan, R. M. (City Coll., Calcutta). Acta Phys. Acad. Sci. Hung.; 26: 407-15(1969).

It is assumed that an unbounded anisotropic electron plasma is linearly polarized under an applied strong magnetic field and the linear distribution of electrons moves with uniform velocity. Electromagnetic intensities and also radiation are slowly damped owing to collisions of electrons but there is no damping in the plane of the external magnetic field and the velocity of the linear distribution of electrons. As a limiting case the expression of Cherenkov radiation for the motion of a line charge in an infinite homogeneous isotropic medium is obtained. (auth)

**15320** REPRESENTATION OF FIELDS IN A RELATIVISTIC PLASMA BY A SURFACE INTEGRAL. Weston, Vaughan H. (Univ. of Michigan, Ann Arbor). Phys. Fluids; 13: 467-71(Feb 1970).

The collective motion of electrons in a relativistic isotropic plasma, which is described by the linearized Maxwell–Boltzmann equations, is treated with time-harmonic dependence. It is shown that the electric intensity at any point in an enclosed volume, can be determined when the tangential components of the electric and magnetic field are prescribed along with the electronic distribution function, on the surface enclosing the volume. (auth)

**15321** RELATIVISTIC NONLINEAR PROPAGATION OF LASER BEAMS IN COLD OVERDENSE PLASMAS. Kaw, Predhiman; Dawson, John (Princeton Univ., N. J.). Phys. Fluids; 13: 472-81 (Feb 1970).

The nonlinear propagation of a very intense laser beam in a cold overdense plasma is analytically investigated; the laser beam is assumed to be intense enough to cause the directed com-

ponent of electron velocity to be comparable to the velocity of light. Special attention has been given to the case when coupled longitudinal-cum-transverse modes propagate in the plasma. An interesting result is that the beam can readily propagate through the overdense plasma, in contrast to what would be expected on the basis of a linear theory of laser propagation. (auth)

**15322** SHOCK WAVES IN SELF-SIMILAR HYDROMAGNETIC SHEAR FLOW: ANALYTIC SOLUTIONS IN A PLANE GEOMETRY. Henriksen, R. N. (Queen's Univ., Kingston, Ont.). Phys. Fluids; 13: 353-63(Feb 1970).

A self-similar form for a one-dimensional magnetogasdynamic shear flow is presented. Discontinuities are found to arise naturally in the course of the self-similar flow and their properties are discussed. It is suggested that the flow adjusts to two-point boundary conditions by a shock transition in cases of practical importance. An analytic solution is given for an initially isothermal medium in the absence of an external force. The solution is valid in different regions of the x-t plane depending on the value of the velocity at $x = 0$ relative to the Alfvén speed, and on the value of the Alfvén speed relative to the sound speed. It is shown how the solutions may be joined together, either continuously or across shocks, to provide a solution that is valid in the whole x-t plane. The effect of requiring two-point boundary conditions is made explicit in these examples. (auth)

**15323** CONTRIBUTIONS TO THE STUDY OF ELECTRIC CONDUCTION THROUGH PLASMA. Mocanu, C. I. Rev. Roum. Sci. Techn., Ser. Electrotech. Energ.; 14: No. 1, 37-51(1969). (In French).

Based on macroscopic considerations, the author demonstrates that the law of electrical conduction in transient conditions assumes an expression different from Ohm's law, steady-state conditions excepted. The frequency dependence of the electrical conductivity and of the Hall constant is developed for a permanent harmonic variation of electric and magnetic parameters. (auth) (Rom. Sci. Abstr.)

**15324** EFFECTS OF NONELASTIC COLLISIONS IN PARTIALLY IONIZED GASES. I. ANALYTICAL SOLUTIONS AND RESULTS. Shaw, J. F.; Mitchner, M.; Kruger, C. H. (Stanford Univ., Calif.). Phys. Fluids; 13: 325-38(Feb 1970).

A self-consistent solution of the coupled free-electron Boltzmann equation and the rate equations for the populations of the excited levels of a monatomic gas is presented, taking into account both nonelastic collisions and radiation losses. Appropriate forms of these equations for a monatomic, partially ionized gas are obtained. Approximate forms of the Boltzmann equation including the effects of nonelastic collisions, are solved analytically to obtain the distribution function. These solutions coupled with an approximate rate equation yield algebraic formulas for the first excited level population. The coupled Boltzmann equation and the rate equations for a model atom provide a qualitative model for predicting the first excited level population, the distribution function, and either the steady-state electron number density, or the net ionization rate. Results based on this model are presented, and include a discussion of the conditions necessary for the validity of the Saha equation at the electron temperature. It is concluded that the effects of nonelastic collisions and radiation loss are largest at low electron number densities and large radiation escape parameters. (auth)

**15325** EFFECTS OF NONELASTIC COLLISIONS IN PARTIALLY IONIZED GASES. II. NUMERICAL SOLUTION AND RESULTS. Shaw, J. F.; Mitchner, M.; Kruger, C. H. (Stanford Univ., Calif.). Phys. Fluids; 13: 339-45(Feb 1970).

A numerical method of obtaining a self-consistent solution of the coupled free electron Boltzmann equation and the rate equations for the populations of the excited levels of a monatomic gas is described, taking into account both nonelastic collisions and radiation losses. An iterative numerical scheme is used to obtain self-consistent electron distribution functions, excited atom level populations, and ionization rates in a monatomic partially ionized gas. A special numerical filtering technique is used to obtain the distribution function. Results for hydrogen plasmas are presented and discussed. It is shown that photon escape and nonelastic collisions cause a depression in the distribution function tail, in the steady-state electron number density, and in the collisional–radiative ionization rate. Large radiation escape factors and low electron number densities lead to large depressions relative to equilibrium values. Results based on the analytical solutions of paper I are compared with the numerical results and found to be in good agreement. (auth)

**15326** SOLVING BOLTZMANN'S EQUATION FOR A FULLY IONIZED PLASMA IN ALTERNATING ELECTRIC AND DIRECT MAGNETIC FIELDS. I. Lupu, Gh. Rev. Roum. Math. Pures Appl.; 14: No. 1, 55-62(1969). (In French).

Series developments of normalized spherical functions and Fourier developments are used, resulting in systems of differential equations. (Rom. Sci. Abstr.)

**15327** SOLVING BOLTZMANN'S EQUATION FOR A FULLY IONIZED PLASMA IN ALTERNATING ELECTRIC AND DIRECT MAGNETIC FIELDS. II. Lupu, Gh. Rev. Roum. Math Pures Appl.; 14: No. 1, 63-9(1969). (In French).

The author resumes the study of the problem considered in Part I, using developments in non-normalized spherical functions. A final equation results wherefrom the equations corresponding to the first approximations are derived. (Rom. Sci. Abstr.)

**15328** GENERAL KINETIC EQUATION FOR WEAKLY TURBULENT HOMOGENEOUS SYSTEMS. Malfliet, W. P. M. (EURATOM–FOM, Jutphaas, Netherlands). Phys. Lett.; 31A: 138-9(9 Feb 1970).

A kinetic equation was found that describes the nonlinear interaction between waves, including the cases of unstable or damped waves. (auth)

**15329** MECHANISM FOR THE BREAKDOWN OF ADIABATIC INVARIANCE. Lichtenberg, A. J.; Jaeger, F. (Univ. of California, Berkeley). Phys. Fluids; 13: 392-6(Feb 1970).

Computation of particle orbits in systems with more than one degree of freedom shows that adiabatic invariance is destroyed due to a resonance between the oscillation periods associated with two degrees of freedom. These resonances can be predicted qualitatively from first-order perturbation theory, which also indicates that the breakdown is related to the percentage change in the invariant during one period of the motion. (auth)

**15330** MODIFICATION OF THE QUASILINEAR THEORY BY TWO-BODY COLLISIONS. Nunez, P.; Rand, S. (Univ. of California, San Diego, La Jolla). Phys. Fluids; 13: 397-401(Feb 1970).

The transfer of energy from the particles of an electron beam to longitudinal plasma waves was studied. The quasi-linear theory, with the inclusion of collision effects, is used. A comparison of the effect of two-body collisions and random wave–particle interactions on the evolution of the distribution function is made. Numerical solutions of the resulting equations are obtained. (auth)

**15331** KINETIC EQUATIONS FOR FULLY IONIZED PLASMAS. Tchen, C. M. (National Bureau of Standards, Washington, D. C.). pp 101-14 of Kinetic Processes in Gases and Plasmas. /Hochstim, A. R. (ed.). New York; Academic Press Inc. (1969).

The following topics are discussed: (1) Liouville equation and BBGKY hierarchy, (2) Vlasov equation, (3) generalized Fokker–Planck equation for slowly and rapidly varying processes, (4) Lenard–Balescu equation, (5) Fokker–Planck equation with memory, (6) Silin kinetic equation for rapidly varying processes, and (7) linearization. (M.O.W.)

**15332** BOLTZMANN AND FOKKER–PLANCK EQUATIONS. Lewis, M. B. (Northwestern Univ., Evanston, Ind.). pp 115-39 of Kinetic Processes in Gases and Plasmas. /Hochstim, A. R. (ed.). New York; Academic Press Inc. (1969).

The Fokker–Planck equation is derived from the Boltzmann equation and from the Markov process. The Boltzmann and Fokker–Planck equations are derived from the Liouville equation. (M.O.W.)

**15333** CALCULATIONS OF TRANSPORT COEFFICIENTS IN IONIZED GASES. Hochstim, A. R.; Massel, G. A. (Inst. for Defense Analyses, Arlington, Va.). pp 141-255 of Kinetic Processes in Gases and Plasmas. /Hochstim, A. R. (ed.). New York; Academic Press Inc. (1969).

The following chapters are included: (1) macroscopic rates and transport coefficients for a plasma, (2) continuity equation and current transport coefficients, (3) ambipolar electron diffusion, (4) ac conductivity and dielectric constant, (5) energy equation and energy transport coefficients, (6) thermoelectric effect and effective coefficient of thermal conductivity, (7) Einstein and Onsager relations between current and energy transport coefficients, (8) generalized Wiedemann–Franz law, (9) kinetic description of ionized gases, (10) general form of the collision integral, (11) spherical harmonics expansion and logarithmic cutoffs, (12) transport properties in slightly ionized gases, (13) transport properties including electron–electron collisions, (14) generalized Ohms' law and Hall coefficients, (15) ion contributions to the transport properties in plasmas, (16) convergence of the Laguerre expansion for electron transport coefficients, and (17) summary of notations, examples, and numerical results for electron transport coefficients. (M.O.W.)

### *Stability*

*Refer also to abstract 15080.*

**15334** STABILIZATION OF ROTATING PLASMA. Ikuta, Kazunari (Nagoya Univ., Japan). J. Phys. Soc. Jap.; 28: 473-7 (Feb 1970).

The interchange instability of rotating plasma is investigated from the thermodynamic point of view. The rotation of plasma tends to stabilize itself in the negative $\delta Y$ configuration, where $Y = \int (r^2/B)dl / \int (1/B)dl$. In the negative $\delta \int (1/B)dl$ configuration with negative $\delta Y$ property the rotating plasma is more stable than the nonrotating one. An example of the negative $\delta Y$ configuration is exhibited. (auth)

**15335** SUPPRESSION OF A PLASMA INSTABILITY BY THE METHOD OF "ASYNCHRONOUS QUENCHING." Keen, B. E.; Fletcher, W. H. W. (United Kingdom Atomic Energy Authority Research Group, Abingdon, Eng.). Phys. Rev. Lett., 24: 130-4 (26 Jan. 1970).

Recent work has shown that an ion-sound instability in a plasma behaves in a manner similar to a classical Van der Pol oscillator. Experimental results are presented which show that the classical method of "asynchronous quenching of a Van der Pol oscillator" can be used to suppress this instability in a plasma. Further, the effects observed as the amplitude and/or frequency are changed and compared with theories due to Minorsky and to Kobsarev (or Bogolyubov). (auth)

**15336** STABILITY OF A SHARP SCREW PINCH. Goedbloed, J. P. (EURATOM-FOM, Jutphaas, Netherlands). Phys. Rev. Lett.; 24: 253-5(9 Feb 1970).

A sharp-pinch model of a dense constant-pressure plasma surrounded by a pressureless plasma with force-free magnetic fields of constant $\alpha$ is shown to be completely magnetohydrodynamically stable with respect to kinks, surface-layer modes, and modes of the pressureless plasma. Its property of having a high shear will also suppress Suydam modes. (auth)

**15337** TRANSVERSE KELVIN-HELMHOLTZ INSTABILITY IN A Q-MACHINE PLASMA. Jassby, D. L.; Perkins, F. W. (Princeton Univ., N. J.). Phys. Rev. Lett.; 24: 256-8(9 Feb 1970).

The Q-machine "edge oscillation" is identified as a Kelvin-Helmholtz instability by a comparison of theory with experiment. Specifically, measurements of frequency and of radial variation in wave phase and amplitude agree with numerical integrations of the radial wave equation, including finite parallel wavelength. The computations show that the instability is caused principally by velocity shear. (auth)

**15338** INTERPRETATION OF EXPERIMENTS ON FEEDBACK CONTROL OF A "DRIFT-TYPE" INSTABILITY. Keen, B. E. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Phys. Rev. Lett., 24: 259-62(9 Feb. 1970).

Previous experimental results on the feedback stabilization of a "drift-type" instability are interpreted in terms of a nonlinear theory of the Van der Pol type. This theory predicts a variation of the instability amplitude and its frequency as a function of the gain and the phase angle in the feedback loop. Comparison between these predictions and the experimental results shows remarkably good agreement. (auth)

**15339** QUASILINEAR EVOLUTION OF THE TRANSVERSE INSTABILITY DRIVEN BY TEMPERATURE ANISOTROPY OF AN UNMAGNETIZED PLASMA. Albright, Norman Webster. Berkeley, Calif.; Univ. of California (1969). 141p.

Thesis.

This instability was first studied by E. S. Weibel (Phys. Rev. Letters, 1959), A. E. Stefanovich (Soviet Physics-Technical Physics, 1962), and F. D. Kahn (J. Fluid Mech., 1962). Starting with a temperature-anisotropic plasma, a spectrum of purely growing magnetic waves develops in k space. These waves cause particle diffusion in velocity space. This leads to temperature isotropy and thus to stabilization of the plasma. After a brief period of rapid diffusion, the anisotropy decreases with time like $t^{-\frac{1}{2}}$. Simultaneously, the wave spectrum shifts to lower and lower wave numbers and eventually decays. (Diss. Abstr.)

**15340** EFFECT OF SHEARED MAGNETIC FIELDS ON ION CYCLOTRON DRIFT INSTABILITIES. Davidson, James Narl. Ann Arbor, Mich.; Univ. of Michigan (1969). 159p.

Thesis.

The effect of magnetic shear on the stability of electrostatic oscillations in an infinite inhomogeneous isotropic plasma is investigated using the linearized Vlasov equations. For oscillations with frequency much smaller than the ion cyclotron frequency, a thorough examination of various approaches including normal mode analysis and the wave packet approach is given, underscoring the various assumptions and approximations and their relevance to the stability criteria. It is found that in the more physically meaningful wave-packet approach a shear angle of the order of the cube root of the ratio of electron to ion masses is sufficient for stabilizing these oscillations. A normal-mode analysis is used to study the effect of shear on electrostatic drift modes with frequency near integral multiples of the ion cyclotron frequency propagating nearly normal to the magnetic field lines. It is found that, in general, shear has a destabilizing effect although it does not alter the overall condition for marginal stability. The wave packet approach is then employed to investigate the stability of these high-frequency oscillations when they propagate at an arbitrary angle to the field lines. For low density plasma, it is shown that the drift cyclotron modes are stabilized by approximately the same shear required to stabilize the low-frequency modes, while at high densities, a more stringent shear is required for stabilization. (Diss. Abstr.)

**15341** EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE ONSET OF STATIONARY CONVECTIVE PLASMA CELLS. Cataldo, Joseph C. New York; City Univ. of New York (1969). 134p.

Thesis.

A low-$\beta$ collisional plasma cylinder confined in a uniform magnetic field is considered. A stationary convective instability, due to the relative rotation of concentric rings of plasma which leads to an adverse angular momentum between these rings, is studied. This mechanism produces a distinct stationary cellular pattern consisting of eight smaller cells around a large central circular hole at a critical magnetic field around 200 G. A new diagnostic instrument, the plasma camera, which allows photographs of the entire column cross section to be taken at one time with a high degree of spatial resolution, is used in a single-ended Q machine to observe the density distribution of the cellular pattern. The onset of the cellular pattern is always accompanied by at least an order-of-magnitude increase in the density. The presence of the hole and the increase in the current density, at low magnetic fields, is the result of effective trapping of particles at the edge of the plasma column. A new concept of anomalous diffusion is presented. The mechanism of this diffusion is due to the breaking off and transverse motion of flute-like irregularities from the central core of the plasma column for magnetic fields above 700 G. The theory of stationary convective instability is used to predict the structure and location of the plasma cells. A stream pattern is theoretically determined that matches the experimentally observed plasma cells. A relationship between the perturbed density and potential is also found to be in good agreement with the experimental values. (Diss. Abstr.)

**15342** TOROIDAL HYDROMAGNETIC EQUILIBRIUM SOLUTIONS WITH SPHERICAL BOUNDARIES. Morikawa, G. K.; Rebhan, E. (New York Univ., N. Y.). Phys. Fluids; 13: 497-500(Feb 1970).

A family of toroidal hydromagnetic equilibrium solutions with spherical boundaries surrounded by a vacuum field is found. Physically relevant singular solutions are included. All solutions are exact with a smooth pressure profile which goes to zero at the plasma-vacuum interface. (auth)

**15343** EVOLUTION AND STABILIZATION OF FLUTES IN A MAGNETIC MIRROR. Colchin, R. J.; Dunlap, J. L.; Postma, H. (Oak Ridge National Lab., Tenn.). Phys. Fluids; 13: 501-12 (Feb 1970).

This paper deals with flutes as observed in a hot-ion, low-$\beta$ plasma. This plasma was established in an adiabatic, simple mirror trap by Lorentz or gas-collisional ionization of an energetic H beam. The studies emphasize: (1) the detailed evolution of the flute mode and comparisons with linear theory and (2) the stabilizing effects of increased electrical connection of the plasma to conducting end walls (line tying). The evolution is traced as a function of density from a stable drift wave at low density to threshold for a growing, unstable wave which quickly exhibited nonlinear frequency behavior. Evolution of the stable drift wave is much as predicted by the linear theories. Instability threshold seems to occur at a somewhat higher density than that calculated even from theories treating bounded plasmas. The line-tying experiments used movable end walls as a control on the electrical connection. Threshold was raised with end walls close to the hot plasma, in a fashion that is in qualitative agreement with a recent calculation. Two possible explanations of the nonlinear frequency behavior of the unstable wave are proposed. (auth)

**15344** ELECTROMAGNETIC INSTABILITY IN AN ELECTRON CYCLOTRON RESONANCE PLASMA. Gitomer, S. J. (Univ. of Pennsylvania, Philadelphia); Shohet, J. L. Phys. Fluids; 13: 413-20(Feb 1970).

An electron cyclotron resonance plasma was produced in a magnetic mirror field. Measurements of electron density, electron temperature, stored energy density, electron energy distribution, plasma light variations, and particle fluxes were made. An instability characterized by microwave emission below the

electron cyclotron frequency, bursts of high-energy x rays, particle losses along the magnetic axis, and variations in stored energy density was observed. The dispersion relation for transverse electromagnetic waves propagating in a plasma with an anisotropic Maxwellian electron velocity distribution with loss cones was solved numerically using parameters characteristic of this experiment and was found to yield instability frequencies and growth rates which agreed well with those observed. (auth)

**15345** NONLINEAR WAVE STABILITY WITH COLLISIONLESS SHOCK APPLICATION. Spero, Donald M. (Columbia Univ., New York); Sen, Amiya K. Phys. Fluids; 13: 459-66 (Feb 1970).

A detailed study of the stability of nonlinear waves in a collisionless plasma has been made. In addition to the ordinary two-stream instability, it has been found that another mode, the cross-stream instability, also plays an important role. The heating of electrons by two-stream instabilities can preclude the existence of nonlinear waves. The cross-stream instability is partly hydromagnetic; it may severely affect the ions and can cause macroscopic breakup of the nonlinear wave. For strong magnetic fields and low temperatures, it is found that the cross-stream instability does not destroy sufficiently weak nonlinear waves. The results are used to construct a collisionless shock wave. (auth)

**15346** FEEDBACK STABILIZATION OF HIGHLY CONDUCTING PLASMAS. Wang, P. K. C. (Univ. of California, Los Angeles). Phys. Rev. Lett.; 24: 362-4(23 Feb 1970).

A general result for the feedback stabilization of surface instabilities of a highly conducting plasma is presented. Explicit form of feedback for stabilizing a linear pinch with a uniform axial static magnetic field is given. (auth)

**15347** A NOTE ON OPTICAL PARAMETRIC BACKWARD-WAVE INSTABILITIES. Cassedy, Edward S.; Evans, C. R. (Polytechnic Inst. of Brooklyn). Proc. IEEE (Inst. Elec. Electron. Eng.); 58: 164-5(Jan 1970).

The Fourier–Laplace integral representation for the field quantities involved in a backward-wave parametric instability is evaluated asymptotically by first performing the integration over $\omega$ and then performing a saddle point asymptotic evaluation of the $\kappa$ integral on the appropriate sheet of $\omega(\kappa)$, the dispersion relation for the parametric medium. The existence of time-growing solutions in an unbounded parametric medium is predicted, and the result shows spatial dependence related solely to the location of the saddle point in the $\kappa$ plane. (auth)

## Thermonuclear Processes

*Refer also to abstracts 14340, 15342, and 15757.*

**15348** (CTO-686) THERMONUCLEAR SYSTEMS WITH DENSE PLASMA. Morozov, A. I. Translated for Culham Lab., Abingdon, Eng., from Vestn. Akad. Nauk SSSR; 39: No. 6, 28-36(1969). 18p. Dep. CFSTI (U. S. Sales Only).

A review-type discussion is given for plasmas with $\beta \lesssim 1$. The basics of Z- and theta-pinch devices are described. Plasma accelerators for use in plasma injection experiments are described also. (M.O.W.)

**15349** (EUR-CEA-FC-533) STUDY OF A POSSIBLE TORSATRON WITHOUT COMPENSATING FIELD. Hubert, P. (European Atomic Energy Community. Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Jan 1970. 12p. (In French). Dep. CFSTI (U. S. Sales Only).

Up to now, the torsatron-type magnetic configuration has been described with a supplementary set of coils required to produce a uniform compensating field parallel to the axis. The calculation presented here gives hope of avoiding those coils when the pitch of the helical conductors is modulated according to an appropriate law. Then an extremely simplified construction would be possible. (France)

**15350** (KHFTI-69-39) DEVELOPMENT AND CONSTRUCTION OF MAGNETIC SYSTEMS FOR THE "URAGAN" STELLARATOR AND STUDIES OF MAGNETIC SURFACES OF LARGE "LATITUDE." Aleksin, V. F.; Biryukov, O. V.; Vishnevetskii, V. N.; (and others) (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1969. 49p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Magnetic surfaces in toroidal stellarators described in the literature are discussed. An attempt was made of selecting magnetic system parameters for the racetrack stellarator Uragan in order to obtain large-"latitude" magnetic surfaces. Design and specifications of the stellarator windings as well as the entire magnetic system are discussed. (R.V.J.)

**15351** (MATT-Trans-97) STUDY OF THE MAGNETIC FIELD STRUCTURE OF THE TOR-2 STELLARATOR. Ivanovskii, M. A.; Popov, S. N. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). Translated for Princeton Univ., N. J., from Preprint No. 124. 27p. Dep. CFSTI.

Measurements were made of the magnetic fields by the electron beam method. The measurements were taken in the range of $\epsilon = B_2/B_0$ from 0.15 to 0.73 ($B_2$ is the amplitude of the helical harmonic, $B_0$ is the longitudinal field). The results are described. (M.O.W.)

**15352** (ORNL-tr-2282) THERMONUCLEAR FUTURE OF MAGNETIC CONFIGURATIONS OF THE TOKAMAK TYPE. Hubert, P. Translated by R. Gregg Mansfield (Oak Ridge National Lab., Tenn.), from Nucl. Fusion; 9: 209-14(1969). 10p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 23: 23188. (M.O.W.)

**15353** MAGNETIC FIELD DEPENDENCE OF DUOPLASMATRON OPERATION. Bose, D. K.; Nagchaudhuri, B. D. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 202-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The values of diffusion coefficients for magnetic fields of 800 to 1600 gauss are compared. The effects on cross diffusion and electron currents are shown. (M.O.W.)

**15354** EXPERIMENTAL THERMONUCLEAR DEVICE URAGAN. Aleksin, V. F.; Biryukov, O. V.; Georgievskii, A. V.; (and others). At. Energ. (USSR); 28: 22-8(Jan 1970). (In Russian).

Constructive and technological features of the stellarator "Uragan" and experimental apparatus for high-temperature plasma confinement research are described. (auth)

**15355** REACTION RATES AND ENERGY SPECTRA FOR NUCLEAR REACTIONS IN HIGH-ENERGY PLASMAS. Lehner, G. (Institut fuer Plasmaphysik, Garching, Ger.). Z. Phys.; 232: 174-89(1970).

Total reaction rates and energy spectra of the generated particles are discussed for fusion reactions in high-energy plasmas. Examples, discussed in some detail, concern elliptic and monoenergetic velocity distributions of the plasma. One obtains energy spectra with very typical shapes that should be useful for diagnostic purposes. This is true, in particular, of reactions between different particles such as the d–t reaction. (auth)

## Wave Phenomena

*Refer also to abstracts 15288 and 15345.*

**15356** (ITF-69-84) ECHO THEORY IN PLASMA SPACIAL ECHO IN PLASMA. Sitenko, A. G.; Nguyen Van Trong; Pavlenko, V. N. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1969. 12p. (In Russian). Dep. CFSTI (U. S. Sales Only).

A consideration is made of the spacial echo effects in plasma which arise as a result of interaction of external perturbations applied in various places of space. There have been considered spacial echo vibrations connected with the transformation of waves in plasma, spacial echo vibrations conditioned by the distribution function perturbations and spacial echo vibrations in nonequilibrium plasma. (auth)

**15357** OBSERVATION OF COLLISIONLESS ELECTROSTATIC SHOCKS. Taylor, R. J.; Baker, D. R.; Ikezi, H. (Univ. of California, Los Angeles). Phys. Rev. Lett.; 24: 206-9(2 Feb 1970).

Large-amplitude ion–acoustic waves ($e\varphi/kT_e \gtrsim 0.3$) are excited in the UCLA double-plasma device by the interpenetration of two plasmas with high electron-to-ion temperature ratios ($6 < T_e/T_i < 20$). A compressional wave with a ramp shape is found to steepen in a fashion consistent with the classical overtaking predicted by the usual Riemann invariants. This steepening continues until dispersive short-scale ($k \approx \frac{1}{2}k_D$) oscillations develop at the front. Ions streaming in front of the shock are also observed. (auth)

**15358** INTERFEROMETER FOR THE MEASUREMENT OF THE FRESNEL DRAGGING EFFECT ON MICROWAVES BY A DRIFTING ELECTRON PLASMA. Gehre, O.; Mayer, H. M.; Tutter, M. (Institut fuer Plasmaphysik, Munich). IEEE (Inst. Elec. Electron. Eng.), Trans. Instrum. Meas.; IM-18: 194-7(Sep 1969).

An apparatus was developed for measuring deviations from reciprocity in the propagation of electromagnetic waves traveling

through a plasma. The apparatus was built for 3-cm waves. The minimum detectable phase difference between the two directions was $\sim 2 \times 10^{-3}$ degree. The apparatus, with the exception of the discharge section, was composed from commercial units. The same could be done for another frequency range. The sensitivity could be further increased by replacing the hand-operated switch by a motor-driven one that could be locked to another coherent detector. The device described above was used to measure the Fresnel effect in plasma. It could also be used to measure sensitively other phenomena characterized by nonreciprocal behavior such as Faraday rotation. (BBB)

**15359** SELF AND MUTUAL INTERACTION OF ELECTROMAGNETIC WAVES IN A MAGNETOPLASMA CONSIDERING THE DEPENDENCE OF ELECTRON DENSITY ON ELECTRON TEMPERATURE. Sawhney, B. K. (Indian Inst. of Tech., New Delhi). J. Phys., A (London); 3: 92-100(Jan 1970).

An expression was derived for the change in electron density in a magnetoplasma arising due to the change in the electron temperature when two electromagnetic waves of frequency $\omega_1$ and $\omega_2$ propagate through it. This expression for the modified electron density is used to derive expressions for the current density due to the electric vectors of the two waves. The expressions thus obtained are substituted in the general wave equation; the solutions of the wave equation are used to investigate the nonlinear self and mutual interaction of the two waves. Some numerical results have been presented in the form of tables to illustrate the dependence of the amplitudes of the waves, for both the processes of mutual and self interaction of the waves, on relevant parameters; these calculations have been carried out for a very particular case when the electron density is assumed to be governed by Saha's equation corresponding to the electron temperature. These numerical calculations suggest that it is important to take account of the variation in the electron density (arising due to changes of ionization and deionization rates) caused by the waves propagating through a plasma. Using the theory developed in this paper, one can obtain the dependence of electron density on temperature from a study of the self and mutual interaction. (auth) (UK)

**15360** SELF-MODULATION OF AN AMPLITUDE-MODULATED WAVE IN MAGNETOPLASMAS. Sodha, M. S.; Sawhney, R. L. (Indian Inst. of Tech., New Delhi). J. Phys., D (London); 3: 168-75(Feb 1970).

A phenomenological theory was developed for nonlinear self-modulation of an amplitude modulated electromagnetic wave, propagating in a magnetoplasma along the direction of the magnetic field, taking both the self interaction and mutual interaction of the two modes into account; unlike presently available theories this theory is not restricted to small value, of the modulation frequency. It is shown that the ordinary mode of propagation becomes demodulated and the extraordinary mode of propagation becomes over-modulated during its propagation through the medium. Further, the change in modulation depth with the frequency of the wave is gradual for the ordinary mode and resonant for the extraordinar mode (around the gyrofrequency). (auth) (UK)

**15361** LONGITUDINAL PLASMA WAVE ECHO EXCITED BY TWO CYCLOTRON WAVES. Kamimura, Tetsuo (Osaka Univ.). J. Phys. Soc. Jap.; 28: 495-504(Feb 1970).

It is shown that successive excitation of two cyclotron waves with a time interval longer than their cyclotron damping periods leads to a spontaneous appearance of a longitudinal plasma wave in a collisionless plasma. The longitudinal plasma wave (i.e., the echo), has the frequency shifted by the cyclotron frequency and appears at the same time as in the case of the excitation by two plasma waves. The line shapes of temporal echoes, together with the phase-mixing processes of the second-order distribution functions, are studied numerically. (auth)

**15362** DISPERSION RELATIONS FOR A COLLISIONLESS PLASMA IN AN APPLIED MAGNETIC FIELD. Weber, James Alec. Lafayette, Ind.; Purdue Univ. (1969). 102p.
Thesis.

The problems of transverse and longitudinal wave propagation through an infinite, unbounded, collisionless plasma immersed in an applied magnetic field are examined using the Maxwell equations of electromagnetic field theory and the Boltzmann-equation statistical description of the plasma. Based on an initial value formulation, the distribution functions and electromagnetic fields are shown to evolve from their initial value. The methods of Laplace and Fourier transform analysis are used in seeking the dispersion relations. Plane wave solutions are sought. Approximations made within the theory include neglecting all radiation magnetic field effects and allowing the electric field dependence on space and time to be expressible in terms of the zero-order particle trajectories. Special attention is given to the dispersion relations which must be satisfied in order for plane wave solutions to exist. It is demonstrated that for cases of purely transverse modes, the method gives the same results as does the method of linearizing the distribution function within the Boltzmann equation when the distribution function is isotropic. For any mode containing a longitudinal component of the electric field our method gives qualitatively the same results as does linearization of the distribution function within the Boltzmann equation. (Diss. Abstr.)

**15363** PENETRATION OF ELECTROMAGNETIC WAVES INTO MAGNETOACTIVE PLASMA. Varma, N. L.; Gupta, R. M. (Univ. of Rajasthan, Jaipur, India). Z. Phys.; 231: 316-23 (1970).

Landau studied the longitudinal field penetration into a semi-bounded plasma considering specularly reflecting electrons at the boundary. Kurilko and Popov and then Gorman examined the same problem considering a fraction "p" of all incident electrons reflecting specularly and the remaining portion diffusely. Lastly, Mason treated the same problem at length and gave solutions for specular and diffuse reflections. Here the penetration of transverse electromagnetic waves into magnetoactive semibounded plasma is studied, and the electric field for specular reflection of electrons is obtained. (auth)

**15364** MICROWAVE-INDUCED IONIZATION OSCILLATIONS IN A RESONANT PLASMA COLUMN. Mendel, C. W. Jr.; Stern, R. A. (Bell Telephone Labs., Inc., Whippany, N. J.). J. Appl. Phys.; 41: 734-7(Feb 1970).

A low-frequency oscillation excited when a low-pressure mercury dc discharge is illuminated near the first thermal Tonks–Dattner resonance with a moderately powerful microwave field was investigated. It was found to be a relaxation oscillation involving enhanced ionization and coupling of the plasma column to the microwave circuit. (auth)

**15365** ION-BURST EXCITED BY A GRID IN A PLASMA. Ikezi, H.; Taylor, R. J. (Univ. of California, Los Angeles). J. Appl. Phys.; 41: 738-42(Feb 1970).

The ion burst excited by a pulsed mesh grid in a plasma is studied experimentally in connection with the sheath structure. The energy distribution of the ions participating in the burst is found to be a broad one. The attenuation of the peak amplitude of the response is confirmed to be due to collisionless damping. The shape of the ion burst is accounted for by the application of the Child–Langmuir law which gives the approximate potential profile of the sheath around the grid. The potential is also measured by using ion transit time effects in the sheath. (auth)

**15366** CYCLOTRON ECHOES IN A WEAKLY IONIZED CESIUM PLASMA. Shaner, J. W.; Hahn, E. L. (Univ. of California, Berkeley). J. Appl. Phys.; 41: 838-40(Feb 1970).

After a calculation of the cyclotron echo amplitude and power expected, microwave pulse measurements were carried out on weakly ionized Cs under conditions of electron–neutral collision dominance. Multiple two-pulse echoes were observed with a maximum power of $10^{-1}$ μW, $10^{-2}$ times that in Ar and in agreement with calculations. The decay time is about 30 to 50 nsec; the amplitude saturated for 1-W pulses, and the electron velocity was $\sim 5 \times 10^7$ cm/sec. Multiple three-pulse echoes were also observed, with a decay rate of ~20 μsec. (D.L.C.)

**15367** ELECTROMAGNETIC RADIATION IN A TIME-VARYING PLASMA. Monroe, Richard L. (Army Mobility Equipment Research and Development Center, Fort Belvoir, Va.). J. Appl. Phys.; 41: 560-2(Feb 1970).

The problem of representing electromagnetic fields in an electron plasma subjected to large and rapid electron-density variations due to transient ionization processes is considered. The inherently nonlinear character of this problem, which arises in the Maxwell–Euler equations through the electron transport term $\nabla \cdot (n\mathbf{V})$, is retained under the assumption that temporal variations of the electron density n are of first order in magnitude while spatial variations in n are of second order. That is, $\mathbf{V} \cdot \nabla n \ll n \nabla \cdot \mathbf{V}$ is assumed and consequently, $\nabla \cdot (n\mathbf{V}) \simeq n \nabla \cdot \mathbf{V}$, where V is the induced velocity field. With the aid of vector and scalar potentials, it is shown that, in this case, the set of ten coupled Maxwell–Euler equations describing a cold, isotropic, lossy, electron plasma with current and ionization sources can be reduced to a set of five integro-differential equations which are effectively decoupled. A method of solving these equations based on perturbation techniques is sketched for the case where the initial electron density is zero. (auth)

**15368** ELECTROMAGNETIC BACKSCATTERING FROM A RANDOM PLASMA SLAB. Hochstim, A. R. (Wayne State Univ., Detroit); Martens, C. P. Phys. Fluids; 13: 402-9(Feb 1970).

The computer method developed by the authors for calculating the electromagnetic scattering from a random, plane parallel

plasma slab is applied to the near-overdense and overdense regimes. The mean reflection coefficient and incoherent reflected power are calculated for an ensemble of random plasma slabs. The results are compared with the analytic solutions using a perturbation expansion of the wave equation to the second order in electric field. Choosing the correlation length of the random amplitudes fluctuation to be equal to that of the random telegraph signal fluctuation results in identical two-point correlation functions for each, but different higher-order correlations. Hence, the computed differences in the scattering calculated for the plasma slabs having the two types of fluctuations are due to the higher-order correlations. (auth)

**15369** RADIO WAVES IN TURBULENT MAGNETOPLASMAS. II. Taylor, Leonard S. (Univ. of Maryland, College Park). Phys. Fluids; 13: 409-12(Feb 1970).

Previous results for the effective index of refraction of a plasma with stochastic variation of density are extended to long wavelengths. It is found that the Born approximation has a more stringent range limitation than has previously been applied and that the scattering cross section is larger. (auth)

**15370** LANDAU DAMPING IN CROSSED-FIELD ELECTRON BEAMS AND INVISCID SHEAR FLOW. Briggs, R. J.; Daugherty, J. D.; Levy, R. H. (Avco Everett Research Lab., Everett, Mass.). Phys. Fluids; 13: 421-32(Feb 1970).

Under certain circumstances the problem of the stability of low-density crossed-field electron beams is precisely analogous to the problem of the stability of incompressible inviscid shear flows. The electron density, the drift velocity, and the potential correspond to the fluid vorticity, velocity, and the stream function, respectively. Neutrally stable normal modes of oscillation that are found when certain suitable step-function unperturbed electron density (vorticity) profiles are assumed seem to disappear when small gradients are present. In the context of a Laplace transform solution of the initial value problem, the vanishing normal modes can be found by analytic continuation of the solution onto another sheet of the cut complex $\omega$ plane. The "recovered" modes are found to be damped by a fluid–wave resonant interaction which closely resembles the Landau damping of plasma oscillations in warm plasmas by particle–wave resonance. An interesting feature of the neutral waves is that they have a negative energy and so are destabilized by the removal of energy from the system (for example, by slightly dissipative walls). The sign and magnitude of the Landau damping term is evaluated for a simple case and compared (for the electronic case) with the growth provoked by slightly lossy walls. (auth)

**15371** ALFVEN WAVE DAMPING FROM FINITE GYRORADIUS COUPLING TO THE ION ACOUSTIC MODE. Stefant, Robert J. (Ames Research Center, Moffett Field, Calif.). Phys. Fluids; 13: 440-50(Feb 1970).

The collisionless damping of shear Alfvén waves in the limit of low frequency and small but finite Larmor radius is discussed. Because the averaging of the wave electric field over the Larmor circle (the so-called finite cyclotron radius effect) creates a small difference in the transverse velocities of the ions and electrons, a longitudinal electric field appears in the Alfvén wave which is responsible for the transfer of the wave energy into the thermal motion of the "resonant" particles $V_z = \omega/k_z$. Numerical solutions (in the complex $\omega$ plane) of the dispersion relation for two wave modes have been obtained: the shear Alfvén mode and the least damped Fried and Gould ion–acoustic mode. The normalized damping rate (Im $\omega$)/(Re $\omega$) has been computed for both waves, and it is shown that the damping factor for the Alfvén wave is maximal when the Alfvén velocity is equal to the real part of the phase velocity of the ion–acoustic wave. Moreover, there exists a particular direction of propagation with respect to the magnetic field for which both the Alfvén and the least damped ion acoustic waves have the same Landau damping. The damping factor for the ion–acoustic wave is a minimum for this particular mode and it is shown that at low values of the electron-to-ion temperature ratio $T_e/T_i$($T_e/T_i \lesssim 2$), the critical drift velocity necessary for instability occurs at a much lower velocity than is usually predicted. (auth)

**15372** NONLINEAR OSCILLATIONS IN A COLLISIONLESS PLASMA. Bailey, V. L. Jr.; Denavit, J. (Northwestern Univ., Evanston, Ill.). Phys. Fluids; 13: 451-8(Feb 1970).

An approximate solution for electron trajectories in a space sinusoidal electric field with a slowly changing amplitude is constructed by varying the modulus of the Jacobi elliptic functions representing electron trajectories in a constant amplitude field. This solution is used, together with energy conservation, to obtain the time behavior of the amplitude of nonlinear longitudinal oscillations in a collisionless plasma. The resulting integrodifferential equation for the amplitude depends on the ratio $\gamma/\alpha_0$, where $\gamma$ is the Landau damping constant, and $\alpha_0$ is the initial value of the frequency of oscillations of trapped electrons in the potential trough of the wave. Numerical solutions are carried out for several values of this ratio. For $\gamma/\alpha_0 \to 0$ (constant amplitude limit) O'Neil's results are recovered. For small but finite values of the ratio $\gamma/\alpha_0$, the present method shows the effect of the energy exchange between resonant electrons and the decaying electric field. The time of regrowth and the corresponding minimum amplitude are evaluated and compared with the results of O'Neil. (auth)

**15373** DIRECT MEASUREMENT OF DRIFT WAVE GROWTH RATES. Rogers, Kenneth C.; Chen, Francis F. (Princeton Univ., N. J.). Phys. Fluids; 13: 513-16(Feb 1970).

Resistive drift waves in a Q machine can be switched on and off by applying a potential to the aperture limiter. The exponential growth of the waves can be directly observed. The measured growth rates are slower than are predicted by the usual theories of collisional drift waves. (auth)

**15374** SCATTERING RESONANCES OF AN ANISOTROPIC HOLLOW PLASMA COLUMN. Shodhan, Kuldip C. (Univ. of Wisconsin, Madison). Proc. IEEE (Inst. Elec. Electron. Eng.); 58: 147-9(Jan 1970).

The scattering of H-polarized plane waves by an infinitely long axially magnetized hollow cylinder of uniform plasma is investigated for the case in which the radius of the plasma column is small in comparison with the wavelength of the incident wave. The total scattering cross section is found to have maxima at two resonant frequencies. The peaks of these resonances are examined in detail, as well as the dependence of their sharpness on the various physical parameters. (auth)

**15375** MODULATED ELECTRON SPECTRUM OF LIGHT SCATTERED BY A MAGNETIZED ARC PLASMA. Kellerer, L. (Institut fuer Plasmaphysik, Garching, Ger.). Z. Phys.; 232: 415-17(1970).

Measuring the spectrum of laser light scattered by a magnetized arc plasma ($n_e = 1.2 \times 10^{16}$ cm$^{-3}$, $T_e = 3.2$ eV, $\alpha = 0.6$, $B_z = 120$ kG) deviations from the normal spectrum were observed. The observed modulation is most probably due to the influence of the magnetic field. Two other less likely possibilities (enhanced electron oscillations or the existence of an additional colder electron component) are discussed. (auth)

# Shielding

**15376** (BNWL–1259) CALCULATION OF GAMMA DOSE RATES AT THE SURFACE OF PLUTONIUM OXIDE SOURCES. Van Tuyl, H. H. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 94p. Dep. CFSTI.

A computer program, PUSHLD, has been developed for calculating gamma dose rates at the surface of plutonium oxide sources. Radiation attenuation due to self-shielding and external shielding were included, along with secondary radiations from Compton scattering, x rays from photoelectric absorption, and electrons from photoelectric absorption. Shielding curves are presented which may be used to determine the surface dose rate from a plutonium source of any isotopic composition and age. Calculated dose rates agreed within 20% with measured values for several plutonium isotopic compositions and three shield materials. (auth)

**15377** (CTC-INF–941) A USERS MANUAL FOR ASOP ANISN SHIELD OPTIMIZATION PROGRAM. Engle, Ward W. Jr. (Union Carbide Corp., Oak Ridge, Tenn. Computing Technology Center). 8 Sep 1969. Contract W-7405-eng-26. 79p. Dep. CFSTI.

ASOP is a one-dimensional shield optimization program based on the one-dimensional discrete ordinates code, ANISN. The code was written for the IBM/360 and will compile on the IBM FORTRAN IV H compiler. ASOP cross section data is required to be coupled neutron and gamma-ray data. In addition to the material cross sections required to describe the shield and any associated, ASOP requires at least one set of activity cross sections which is used to compute the dose rates due to neutrons and gamma rays. (M.H.R.)

**15378** (EGG–1183-1449) MEASURED LOW-ALTITUDE NEUTRON AND GAMMA DOSE DISTRIBUTIONS DUE TO A 14-MeV NEUTRON SOURCE. Technical Report No. L-955. Fritzsche, A. E.; Lorimier, N. E.; Burson, Z. G. (EG and G, Inc., Las Vegas, Nev.). 21 Aug 1969. 67p. Dep. CFSTI.

Neutron and gamma dose distributions due to a 14-MeV neutron source were measured for many source–detector geometries in a large vertical plane above the ground/air interface. The purpose of the measurements was to describe the neutron and gamma tissue

dose distributions as a function of source height, detector height, and slant range (source–detector separation). The doses were obtained in the most detail at a 3-ft detector height for 27- through 1125-ft source heights. Dose measurements at other detector heights were more limited in extent. Principal characteristics of the dose distributions found were: (1) The ground appears to reflect neutrons (increase the dose) close to the source and absorb them far from the source. This is similar to the behavior for a fission neutron source. (2) The dose near the ground at a given slant range increases appreciably as the source is raised above the ground. (3) The ground reflection and absorption effect (ground perturbation) increases as the detector approaches the ground. (4) The ground produces more gammas than the air it displaces. (auth)

**15379** (NP-tr-1864) CALCULATING THE PASSAGE OF NEUTRONS IN SPHERICAL GEOMETRY BY THE MONTE CARLO METHOD. Van'kov, A. A.; Mikhailus, F. F. Translated from pp 131-48 of Metod Monte Karlo v Probleme Perenosa Izluchenii, Atomizdat, Moscow, 1967. 13p.

Considering true spherical geometry, it is assumed that the isotropic point source of neutrons is located in the center of the spherical cavity. The following notation is introduced: $R_1$, $R_2$ — the radii of the spherical envelope ($R_1 < R_2$); $\Sigma_{tr}$ and $\Sigma_a$ are the macroscopic complete transport profile and the profile of absorption; T is spherical passing of neutrons through the sample. The formula for relative absorption is represented in the following way: $1-T = \delta_0\alpha\{1 + (1/\delta_0)[K_1\beta + K_2\beta^2 + \ldots + (K_n\beta^n/1-\beta\gamma_n)]\}$, where T is spherical passage; $\delta_0 = 1-e^{-\Sigma_t(R_2-R_1)}$; $\alpha = (\Sigma_a/\Sigma_{tr})$; $\beta = 1-(\Sigma_a/\Sigma_{tr})$; and coefficients $K_1$, $K_2$, ... $K_n$, $\gamma_n$ are functions of parameters: $a = (R_1/R_2)$, $[0 + 1]$; $b = \Sigma_{tr}(R_2-R_1)$, $[0 + \infty]$. The results of the calculations are shown in tables where $K_1$, $K_2$, $K_n$, $\gamma_n$ coefficients are computed with sufficiently detailed steps with the intervals (0 to 1) for a and (0 to 7) for b, which corresponds to the possible variations of samples with thicknesses of up to 7 free path lengths. (M.H.R.)

**15380** THEORETICAL DOSE TRANSMISSION AND REFLECTION PROBABILITIES FOR 0.2 TO 10.0 MeV PHOTONS OBLIQUELY INCIDENT ON FINITE CONCRETE BARRIERS. Doggett, W. O. (North Carolina State Univ., Raleigh); Bryan, Fred A., Jr. Nucl. Sci. Eng.; 39: 92-104(Jan 1970).

Berger et al. of the National Bureau of Standards have utilized the Monte Carlo method to calculate total scatter differential dose transmission and reflection coefficients for plane unidirectional gamma rays incident on concrete barriers of finite thickness. These calculations were performed for source energies of 0.2, 0.4, 0.66, 1.25, 5.0, and 10.0 MeV with incident obliquity angles cos $\theta_0$ = 1, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1, 0.01; emergent obliquity angles cos $\theta_d$ = 1, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1, 0.01; emergent azimuthal angles relative to the ongoing incident ray $\phi$ = 0, 30, 60, 90, 120, 150, and 180 degrees; and slab thicknesses of 0.25, 0.5, 0.75, 1, 2, 3, and 4 mean-free-paths. These data are used herein to compute dose rate slant penetration and reflection probabilities for a detector located adjacent to a barrier. The total scatter contribution was calculated by numerically integrating the Monte Carlo data of Berger et al. over the $2\pi$ solid angle subtended by the barrier relative to the detector location. In addition to results for the above listed thicknesses, energies, and incident obliquities, slant penetration and reflection probabilities are computed for the 1.12 h unfractionated fission spectrum by interpolating and weighting the Monte Carlo data at appropriate energies and thicknesses. The probabilities obtained herein compare favorably with those obtained by the Spencer–Fano moments method for an infinite medium, with other Monte Carlo studies, and with experimental data. (auth)

**15381** RADIATION TRANSPORT CALCULATIONS: FORE AND AFT APPROXIMATION. Daley, J. T. (Republic Aviation Corp., Mineola, N. Y.). J. Appl. Phys.; 41: 468-71(Feb 1970).

An approximate method for describing radiation transport is derived. Photoelectric effect and Compton effect are assumed to be the only mechanisms affecting the transport. Thus the method is restricted to the x-ray and low-energy gamma-ray region of the electromagnetic spectrum. Further, the radiation is assumed to be a collimated beam incident normal to a homogeneous semi-infinite slab. The method goes one step beyond the classical "straight-ahead" approximation used in the theory of gamma-ray attenuation. Because of the assumptions used in obtaining the solution, the expressions derived can most appropriately be applied for the case where Compton scattering is near isotropic (relatively low energies) and where the photoelectric cross section is larger than the Compton cross section. (auth)

**15382** TWO DIMENSIONAL SHIELDING CODE RSC-2D. Kawasaki Giho; No. 36, 34-40(Jan 1970). (In Japanese).

The RSC-2D is a two-dimensional shielding code in R–Z direction programmed in 3600 FORTRAN for the CDC 3600. It consists of three independent programs, MENDIP for group constants, R 68 for removal neutron source calculation and S 68 for multi-group neutron diffusion calculation. Maximum number of groups for removal and diffusion scheme is 18 and 30 respectively. Energy transfer is only allowed from higher groups to lower. It is possible to divide a shield system by 10 × 10 regions in maximum for removal and diffusion scheme. There may be up to 99 × 99 mesh points for diffusion calculations. Some results of calculations are shown. (NSA of Japan)

# Solid-State Physics

*Refer also to abstract 14825.*

## Radiation Effects

*Refer also to abstracts 14982 and 15130.*

**15383** (COO-1800-9) THE FUNDAMENTALS OF RADIATION DAMAGE. Progress Report, February 1, 1969–February 1, 1970. Sosin, A. (Utah Univ., Salt Lake City). Contract AT(11-1)-1500. 18p. Dep. CFSTI.

After an account of equipment development (cryostats, accelerators, etc.), work on the Stage I annealing of electron-irradiated Cu is summarized. Other experimental and theoretical research is described briefly; some data on Young's modulus and internal friction in irradiated Cu are given. (D.L.C.)

**15384** PULSED NUCLEAR MAGNETIC RESONANCE OF GAMMA-IRRADIATED LITHIUM HYDRIDE. Souers, P. C.; Blake, T. S.; Penpraze, R. M.; Cline, C. (Univ. of California, Livermore). J. Phys. Chem. Solids; 30: 2649-56(Dec 1969).

Some of the effects of $^{60}$Co gamma irradiation on lithium hydride are described. Volume increase and nuclear magnetic resonance data are given for samples irradiated from 40 to 395°C. Maximum swelling occurs between 160 and 200°C; negligible swelling occurs above 300°C. Motionally narrowed proton and $^7$Li nuclear magnetic resonance signals appear on irradiation and increase with increasing swelling. These decomposition products, which are trapped inside the LiH, can amount to more than one-tenth the total sample at doses of ~50 G Rad. At this point, ~25 volume per cent swelling has occurred and the growth rate has subsided. The hydrogen nuclear magnetic resonance signal has been shown to come from $H_2$ molecules by observation of the ortho-para conversion on cooling. Hydrogen densities derived independently from the longitudinal relaxation time and the swelling data are in reasonable agreement. The corresponding gas pressures range from 750 to 5000 atm. The $H_2$ is thought to be in bubbles which cause the volume growth, and recent electron microscopy results support this view. The $^7$Li signal has a Knight shift, and the lithium is present as metal particles. Above 200°C, the $H_2$ and Li back-react rapidly. Above 300°C this reaction takes place as fast as the decomposition which was caused by the irradiation. (auth) (UK)

**15385** EVIDENCE FOR A DEFECT CONVERSION MECHANISM IN COPPER. Thompson, D. O.; Buck, O. (North American Rockwell Corp., Thousand Oaks, Calif.). Phys. Status Solidi; 37: 53-63(1 Jan 1970).

The effects of $\gamma$-ray irradiation upon the internal friction and Young's modulus of copper have been measured in the temperature range from 81 to 241°K. It is found that there exists a pronounced minimum in the rate at which defects arrive at dislocations in the vicinity of 170 to 180°K. This minimum is discussed and its significance in terms of the two predominant radiation damage models is considered. (auth)

**15386** STUDY OF V CENTERS STABLE AT ROOM TEMPERATURE IN NaCl(Ca) CRYSTALS. Voszka, R.; Watterich, A. (Crystal Physics Research Lab., Budapest). Acta Phys. Acad. Sci. Hung.; 27: 277-87(1969).

Following x-irradiation of OH-free NaCl(Ca) crystals at room temperature, new absorption bands were observed at 360, 336, and 193 nm wavelengths, in addition to the $V_2$ band appearing in pure crystals at 223 nm. These new bands were assigned to $V_F$, $V_F^M$, and $V_2^M$ centers, respectively. The M superscript refers to the presence of the divalent metal impurity, thus distinguishing the centers from similar centers in the pure crystal. In the case of x irradiation at −80°C, a new band was observed at 330 nm and shown to be due to $V_K^M$ centers. The models of the appearing centers are well-known, except in the case of $V_F^M$ centers for which a model is proposed. (auth)

**15387** SEARCH FOR CHEMICALLY BOUND NEUTRONS. Krohn, V. E.; Perlow, G. J.; Ringo, G. R.; Ruby, S. L. (Argonne National Lab., Ill.). Phys. Rev. Lett.; 23: 1475-6(29 Dec 1969).

An attempt to confirm the chemical binding of neutrons reported by Grant and Cobble [(Phys. Rev. Lett., 23: 741-4(1969)], using neutron fluxes 10 to 1000 times larger than theirs, led to a negative result. (auth)

**15388** SIMULTANEOUS MEASUREMENT OF CHANNELING EFFECTS ON THE SPUTTERING AND BACKSCATTERING PROCESSES. Reuther, E.; Bradford, J. N. (Kansas State Univ., Manhattan). Phys. Rev.; 188: 654-6(10 Dec 1969).

Sputtering and backscattering yields have been simultaneously measured for beams of H, He, and N incident on a single Au crystal near the ⟨110⟩ axes. The angular half widths $\psi_{\frac{1}{2}}$ of the yield minima produced by crystal rotation were measured and compared with the low-energy critical-angle prediction of Lindhard. Dechanneling effects were observed to play a major role in determining the magnitude and energy dependence of the observed minima. (auth)

**15389** ELECTRON PARAMAGNETIC AND NUCLEAR DOUBLE RESONANCE OF $F^+$ CENTERS IN BeO SINGLE CRYSTALS. DuVarney, R. C.; Garrison, A. K.; Thorland, R. H. (Emory Univ., Atlanta). Phys. Rev.; 188: 657-61(10 Dec 1969).

Single crystals of BeO which have been irradiated with neutrons show an EPR spectrum with partially resolved hyperfine. An ENDOR study of the hyperfine interaction leads to the conclusion that the spectrum arises from centers which consist of an electron trapped at an oxygen vacancy surrounded by four Be nuclei. The measured hyperfine interaction constants are: $A_\perp/h = 10.3$ MHz, $A_{II}/h = 16.4$ MHz, and $(e^2qQ)/h = 1.1$ MHz for the Be nuclei not on the c axis; and $A_\perp/h = 4.2$ MHz, $A_{II}/h = 9.2$ MHz, and $(e^2qQ)/h = 1.5$ MHz for the nuclei along the c axis. These values lead to $|\phi(r_{Be})|^2 = 0.13 \times 10^{24}$ cm$^{-3}$ for the electron wave function at the c-axis nuclei, and $|\phi(r_{Be})|^2 = 0.06 \times 10^{24}$ cm$^{-3}$ for the non-axial nuclei. The measured g value for H parallel to the c axis is 2.0030. (auth)

**15390** CONCENTRATION DEPENDENCE OF FRENKEL-PAIR-DEFECT ANNEALING IN ELECTRON-IRRADIATED Ta AND Nb. Myhra, Sverre; DeFord, John W. (Univ. of Utah, Salt Lake City). Phys. Rev.; 188: 1093-1100(15 Dec 1969).

An investigation was conducted on the dose dependence of the annealing spectra of Ta and Nb from 15 to 285°K after bombardment with 2.2-MeV electrons. Ta and Nb samples were irradiated to different defect concentrations, then simultaneously annealed isochronally from 14.7 up to 285°K. In Ta, recovery peaks were observed at 23, 51, 65, 123, and 170°K. The position of the peak near 170°K is dose-dependent and shows the characteristics of a second-order reaction. In Nb, recovery peaks were observed at 26.5, 58, 95, and 135°K. The peak at 95°K is dose-dependent and follows second-order kinetics initially, with an apparent shift to higher order toward the end of the stage. A two-interstitial model seems to give the best fit to the data. (auth)

**15391** MEASUREMENTS OF THE THRESHOLD DISPLACEMENT ENERGY IN Ta AND Nb. Youngblood, G.; Myhra, S.; DeFord, J. W. (Univ. of Utah, Salt Lake City). Phys. Rev.; 188: 1101-7(15 Dec 1969).

Changes in the damage rate (residual electrical resistivity per unit electron fluence) were measured as a function of incident electron energy in the range 1.0 to 2.2 MeV for 0.002-in.-dia. Nb and Ta wires. The threshold energies, estimated by simple extrapolation to zero production rates, were 36 eV for Nb and 32 eV for Ta. The resistivity of a Frenkel pair was determined to be about 5.3 μΩ cm/at.% for Nb and 1.9 μΩ cm/at.% for Ta. The damage production curves for two other bcc metals, Mo and W, are compared with those for Nb and Ta. (auth)

**15392** THE DETECTION OF HYPERFINE STRUCTURE IN THE EPR SPECTRUM OF A TRAPPED ELECTRON IN γ-IRRADIATED ALKALINE GLASSY ICE AT 77°K. Ershov, B. G.; Pikaev, A. K. (Inst. of Physical Chemistry, Moscow). Radiat. Eff.; 2: 135-6(Jan 1970).

A triplet was found in the EPR spectrum of γ-irradiated 10M alkaline glassy ice with a [H]/([H] + [D]) ratio of ~0.11. The side components of the triplet could be detected, and the splitting is 6 ± 1 Oe, in agreement with calculation. (D.L.C.)

**15393** DEFECTS OBSERVED IN ELECTRON-IRRADIATED PURE SILVER BY ELECTRON MICROSCOPY. Shimomura, Y. (Univ. of Illinois, Urbana). J. Appl. Phys.; 41: 749-59(Feb 1970).

Nominally 99.9999% pure silver strips were irradiated near 140°K with 3-MeV electrons. Fluences ranged from 0.05 to 6.7 × $10^{18}$ electrons/cm$^2$. In order to observe defects which exist in irradiated specimens by electron microscopy at temperatures below stage III annealing, specimens were thinned, washed, and mounted on a specimen holder below −60°C. They were also dried below −60°C and observed using a liquid-nitrogen cooling stage. A large number of interstitial loops were observed below stage III. The number of loops was constant but the size of the loops increased with increasing fluence. They shrank and disappeared during stage III annealing. After annealing at 0°C, another kind of small dot defects were observed. The results suggest that the stage III annealing occurs by a vacancy or divacancy migration in electron irradiated pure silver. (auth)

**15394** INTERPRETATION OF EMERGENT STAR PATTERN DISTRIBUTIONS FOR MeV PROTONS TRANSMITTED THROUGH SINGLE CRYSTALS. Appleton, B. R.; Feldman, L. C. (Bell Telephone Labs., Inc., Murray Hill, N. J.). Radiat. Eff.; 2: 65-8 (Jan 1970).

The emergent distributions of protons transmitted through thin single crystals parallel to low-index directions display characteristics consistent with the general notions of particle channeling. Certain aspects of these patterns, however, have been used as evidence for the desirability of a wave or diffraction description of the phenomena. This paper presents detailed energy and intensity measurements for silicon and show that they can be understood in terms of the classical channeling picture. (auth)

**15395** STORED ENERGY AND ELECTRICAL RESISTIVITY OF FRENKEL DEFECTS IN COPPER. Losehand, R.; Rau, F.; Wenzl, H. (Technische Hochschule, Munich). Radiat. Eff.; 2: 69-74(Jan 1970).

Simultaneous measurements of the recovery of stored energy and electrical resistivity were performed in a differential heat flux calorimeter after neutron irradiation at 4.6°K (linear rising of temperature from 6 to 250°K, with variable velocity between 0.3 and 2°K/min). At each main recovery stage, the heating was interrupted and repeated after cooling down to 6°K to determine the change of specific heat due to the defects. The contribution of the vibrational energy change to the stored energy is not negligible. Defects anneal in stage I (4°K < T < 55°K) with $\Delta Q/\Delta\rho = 42.6/21.4$ Ws/Mol · nΩcm. Within experimental error, there was no effect in specific heat. Defects anneal in stage II and part of stage III (65°K < T < 250°K) with $\Delta Q/\Delta\rho = 114/31$ Ws/nΩcm · Mol, $\Delta C/C \cdot \Delta\rho = +8/31$ per cent/nΩcm, where $\Delta Q$ is the stored energy, $\Delta\rho$ the change of residual resistivity and $\Delta C$ the change in specific heat. The measured changes of the Debye temperature are in agreement with those of the characteristic temperature in the Grüneisen model of the electrical resistivity. The ratios of the stored energy to the residual resistivity in the diverse recovery stages are discussed. (auth)

**15396** PRESSURE INDUCED ANNEALING OF DEFECT CLUSTERS AND HARDNESS INCREASE IN IRRADIATED MOLYBDENUM. Kulcinski, G. L.; Mastel, B. (Battelle Memorial Inst., Richland, Wash.). Radiat. Eff.; 2: 75-80(Jan 1970).

Irradiation of high-purity molybdenum to 6.2 × $10^{18}$ n/cm$^2$ (E > 1 MeV) at 40°C produces 3.7 × $10^{16}$ observable defect clusters/cc and a 19% increase in the Vickers hardness of the metal. Post-irradiation annealing studies were conducted at two pressures: ≤1 bar and 20 kbar. The low-pressure studies reveal that temperatures of 800 and 1000°C are required to remove the defect clusters and the hardness increase, respectively. Annealing at high pressure lowers both the temperature at which the clusters are removed and the temperature at which the hardness recovers by ~300°C. The recovery of the irradiation-induced hardness appears to be related, in a complex manner, to the recovery of observable defect clusters in both low- and high-pressure anneals. (auth)

**15397** ELIMINATION OF POINT DEFECTS BY DEFORMATION AT 78°K IN ALUMINUM IRRADIATED BY NEUTRONS. Dimitrov, C.; Dimitrov, O. (CNRS, Vitry-sur-Seine, France). Radiat. Eff.; 2: 81-90(Jan 1970). (In French).

Pure aluminum samples, neutron-irradiated at 78°K, were deformed by compression at the same temperature. Deformation does not produce an increase in low-temperature electrical resistivity, but a decrease. The decrease corresponds to the elimination at 78°K of a fraction of the radioinduced defects which would recover in stage III. This elimination is produced by the movement of dislocations through the metal. It is shown that the process involved is probably a destruction of radioinduced point-defect clusters. (auth)

**15398** ENERGY LOSS OF HEAVY IONS ALONG LONG-INDEX DIRECTIONS IN GOLD SINGLE CRYSTALS. Boettiger, J.; Bason, F. (Univ. of Aarhus, Denmark). Radiat. Eff.; 2: 105-10(Jan 1970).

The electronic stopping of heavy ions with $7 \leq Z_1 \leq 54$ in low-index directions of thin gold single crystals is measured in the energy range 200 keV ≤ E ≤ 1100 keV. Large oscillations in electronic stopping power are observed for constant ion velocity. The stopping powers of different low-index directions are compared. (auth)

**15399** EFFECTS OF NEUTRON IRRADIATION ON THE OPTICAL PROPERTIES OF THIN FILMS AND BULK GaAs AND GaP. Pankey, T. Jr.; Davey, John E. (Naval Research Lab., Washington, D. C.). J. Appl. Phys.; 41: 697-702(Feb 1970).

GaAs and GaP thin film and bulk samples have been irradiated with neutron fluences of $10^{18}$ nvt and the effect on the optical absorption edge and free carrier region determined. In the case of both GaAs and GaP films, which exhibit bulk or near bulk optical properties before irradiation, large optical absorption edge shifts of ~0.3 and ~1.5 eV, respectively, are caused by the neutron bombardment. These optical absorption edge shifts can be "annealed out" by high-temperature vacuum annealing; in the case of the GaAs films, isochronal annealing points to a Frenkel-pair annihilation mechanism. Bulk samples of GaAs and GaP, similarly irradiated, exhibit smaller optical edge shifts than the films with substantially different quantitative behavior. High-temperature vacuum annealing of the bulk samples also results in a recovery of normal optical properties. (auth)

**15400** ESR OF ELECTRON-IRRADIATED ZnO: CONFIRMATION OF THE $F^+$ CENTER. Smith, J. M.; Vehse, W. E. (West Virginia Univ., Morgantown). Phys. Lett.; 31A: 147-8(9 Feb 1970).

Irradiation of single crystals of ZnO with 2-MeV electrons produces a defect which has been identified by its ESR spectrum as an $F^+$ center. A correlation between this center and the radiation-induced optical absorption has been observed. (auth)

**15401** X-RAY-INDUCED CONDUCTIVITY CHANGES IN Ge. Kreutz, E. W.; Waidelich, W. (Technische Hochschule, Darmstadt, Ger.). Phys. Lett.; 31A: 117-18(9 Feb 1970).

Electrical conductivity changes of p-type Ge were measured during x irradiation at T = 79°K. Thermally stimulated current measurements are presented. Possible explanations are given for the negative and positive radiation-induced conductivity changes. (auth)

**15402** NEW ABSORPTION BANDS IN X-IRRADIATED FLUORITE. Maurizot, Jacqueline; Palmari, Jean-Pierre (Univ., Marseille). Compt. Rend., Ser. B; 270: 219-22(19 Jan 1970). (In French).

Fluorite single crystals exposed to x rays at room temperature show a coloration, either violet (type I crystals) or rose (type II crystals). Type I samples have a classical absorption spectrum; type II samples have a complex spectrum which, after heat treatment, resolves itself into a two-band spectrum (2150 and 5300 Å), probably of colloidal origin. (France)

**15403** VARIATIONS OF NONADDITIVITY OF ELECTRO- AND X-RAY LUMINESCENCE OF ZnS:Cu PHOSPHORS. Kolomoitsev, F. I.; Kodzhespirov, F. F.; Sidorenko, S. M. Zh. Prikl. Spektrosk.; 9: 1000-4(Dec 1968). (In Russian).

Studies of the nonadditivity of luminescence of EL-460 type phosphors simultaneously excited by sinusoidal electric fields and x irradiation showed the nonadditivity depends on the amplitude and frequency intensities of the x radiation. It is possible to select a critical frequency $f_{cr}$ at which the electro- and x-ray luminescence are identical. In the phosphor examined the spectrum contained two bands with 400 and 520 nm maximums. Passing the $f_{cr}$ the nonadditivity variation changes its term. The positive nonadditivity rises with increase of the frequency and upon reaching saturation. (R.V.J.)

## Physical Properties

*Refer also to abstracts 14679, 14750, 14790, 14948, and 15430.*

**15404** MAGNETIC SUSCEPTIBILITY OF HEPTAVALENT NEPTUNIUM. Chaikhorskii, A. A.; Romanov, G. A. Radiokhimiya; 11: 598-600(1969). (In Russian).

The magnetic susceptibility of Np(VII) salts was measured in solutions and in the solid state. Diagrams were constructed of the magnetic susceptibility as a function of temperature and the number of electron pairs. It was found that the diamagnetic susceptibility of Np(VII) differs significantly from that of Np(VI). (R.V.J.)

**15405** EXTRAORDINARY HALL EFFECT IN PARAMAGNETIC GADOLINIUM FILMS. Wald, Francine J. Brooklyn; Polytechnic Inst. of Brooklyn (1969). 124p.

Thesis.

The extraordinary Hall coefficient was measured in paramagnetic gadolinium films in a temperature range up to 65° above the Curie point using a technique for studying ferromagnetic resonance in thin films through nonlinear microwave interactions developed by Egan and Juretschke. The measurements show that at microwave frequencies, the extraordinary Hall constant is independent of temperature between 305 and 360°C. As the temperature is reduced below 305°C, the absolute value of $R_s$ increases rapidly but smoothly. Detailed analysis of the resonance curves and the results of the dc measurements made on the films indicate that the g-value, paramagnetic relaxation time, and resistivities of the gadolinium films are within 10% of the bulk values, although the magnetic susceptibilities of the films are appreciably lower than the bulk susceptibility. It was also established that there is significant preferred c-axis orientation normal to the film plane. The extraordinary Hall constant measured on the paramagnetic gadolinium films is a smooth extension of the single crystal results (H || c-axis) for ferromagnetic bulk gadolinium reported by Lee and Legvold. The high-temperature results agree qualitatively with those of Volkenshtein and Fedorov and with those of Babushkina for bulk gadolinium. Quantitatively the results differ from both Volkenshtein's and Babushkina's reported values. The temperature independence of $R_s$ at high temperatures is inherent in Kondo's theory of the anomalous Hall effect in gadolinium metal. This theory used in conjunction with recent calculations of the band structure and the polarized electron density distributions for gadolinium explain the large extraordinary Hall effect and measured g-value. (Diss. Abstr. Int., B)

**15406** A STUDY OF MAGNETIC FIELD INDUCED SURFACE STATES IN METALS AND SEMIMETALS. Jensen, James Darrell. College Park, Md.; Univ. of Maryland (1969). 96p.

Thesis.

The microwave surface impedance of bismuth, indium, and gallium was investigated at liquid helium temperature in the frequency range 32 to 55 GHz. The derivative of the surface resistance (dR/dH) oscillates when a weak magnetic field is applied parallel to the surface. The derivative maxima correspond to transitions between pairs of allowed magnetic field-induced surface states. The spectrum and lineshape of the transitions are given by the Prange–Nee theory of these surface states. The relative positions of the resonance fields are the same for all metals and do not involve Fermi surface (FS) parameters. However, the absolute positions of the resonance fields could be calculated for bismuth since the relevant FS parameters are reasonably well known from de Haas–van Alphen and cyclotron resonance measurements. The good agreement between the resonance field calculated from the theory and the corresponding dR/dH maximum provides a detailed confirmation of the Prange–Nee theory. This agreement assures that FS information can be extracted from the resonance fields when the shape of the FS is known. Electron velocities, at selected points on the smallest central cross section of the bismuth electron ellipsoid, were calculated from the resonance fields using de Haas–van Alphen data fitted to an ellipsoidal FS model. The velocity varies over this section from $7.9 \times 10^7$ to $1.02 \times 10^8$ cm/sec. The anisotropy of the resonance fields was investigated under various geometrical arrangements of the bismuth electron ellipsoid and the static magnetic field relative to the sample surface. The anisotropy is in accord with the predictions of a cylindrical FS. Magnetic field-induced surface states were also studied in indium and gallium. The shape of the FS is not sufficiently known in either of these metals to permit Fermi velocities to be calculated from the resonance fields. Anisotropy data were taken in the major symmetry planes of indium in an attempt to identify the regions of the FS which were responsible for the observed microwave absorption spectra. The absorption spectrum of gallium contained a large number of peaks and provided a check on the theory for high-order transitions. (Diss. Abstr.)

**15407** EFFECT OF ADDITION OF MOLYBDENUM ON CHARACTERISTIC PROPERTIES OF NEW HIGH-MAGNETIC PERMEABILITY ALLOYS "NIMALLOY" IN THE SYSTEM OF NICKEL AND MANGANESE. Masumoto, Hakaru; Kobayashi, Takeo; Murakami, Yuetsu (Research Inst. of Electrical and Magnetic Alloys, Sendai). J. Jap. Inst. Metals, 33: 1141-5 (Oct. 1969). (In Japanese).

A series of experiments on the effects of additions of various elements on the properties of Nimalloy were conducted. The highest initial permeability of 76,000 and the highest maximum permeability of 441,000 were observed. The results showed that with increasing addition of Mo to Ni–Mn binary alloys, the cooling rate required to attain the highest permeability became smaller. Accordingly, most of the alloys were baked for a long time at a temperature below the order–disorder transformation point after slow cooling from 900°C. In the case of Mo additions, both the initial and maximum permeabilities increased gradually to maxima and then decreased gradually. The nickel alloy containing 18.63% Mn and 3.70% Mo showed the highest initial permeability of 13,720 and the highest maximum permeability of 113,400 when baked at 400°C for 340 and 210 hr after cooling at 5°C/hr from 900°C, respectively. The alloy of the highest maximum permeability showed a coercive force of 0.0240 Oe and a hysteresis loss

of 36.24 erg/cm³/cycle for the maximum magnetic induction of 5,000 G, an intrinsic magnetic induction of 8,010 G at 900 Oe and an electrical resistivity of 58.8 μΩ-cm at 20°C. (auth)

**15408** MAGNETIC PROPERTIES OF A GADOLINIUM SINGLE CRYSTAL. Feron, Jacques-Louis; Pauthenet, Rene (CNRS, Grenoble, France). Compt. Rend., Ser. B; 269: 549-52(29 Sep 1969). (In French).

Using for the anisotropic energy the phenomenological form $W_a = K_1 \sin^2 \theta + K_2 \sin^4 \theta$, and starting from the magnetization curves, the thermal variations of the constants of anisotropy $K_1$ and $K_2$ of gadolinium and of the zenith angle $\theta_0$ of the weak magnetization cone are determined. (tr-auth)

**15409** EFFECT OF A UNIAXIAL STRESS ON THE CURIE TEMPERATURE OF A SINGLE CRYSTAL OF Gd. Bartholin, Henri; Bloch, Daniel (CNRS, Grenoble, France). Phys. Rev.; 183: 845-8(10 Dec 1969).

The variation of the Curie temperature of a single crystal of Gd when subjected to a uniaxial stress up to 130 bar applied along the c axis of the crystal, is $(-1.55 \pm 0.05) \times 10^{-3}$ deg bar$^{-1}$. The rate of change with a stress applied along the a or b axis is $(0 \pm 0.05) \times 10^{-3}$ deg bar$^{-1}$. The variations of the exchange interaction with the a, b, and c crystallographic parameters are deduced, together with the variation of the Curie temperature with hydrostatic pressure, the magnetic length anomaly along the various crystallographic axes, and the anisotropic forced magnetostriction. The calculated values are in good agreement with the experimental values. (auth)

**15410** THEORY OF POSITRON ANNIHILATION IN INERT-GAS SOLIDS. Salvadori, A. (Guelph Univ., Ontario); Carbotte, J. P. Phys. Rev.; 188: 550-6(10 Dec 1969).

The lifetime of a positron in solid argon was calculated as a function of two-quantum decay and the angular correlation of the resulting $\gamma$ pair. The shape of the angular distribution obtained is in close agreement with experiment, and the area under it gives the measured total rate to within 15%. The calculations are based on a general theory that was developed for annihilation in metals but is also applicable with slight modifications to simple nonionic insulators like the inert-gas solids where a single decay mode is observed. The point is simply that all electrons can be treated as core electrons, and the expressions previously derived for core annihilation in metals can readily be adapted to simple nonionic insulators. (auth)

**15411** CALORIMETRIC INVESTIGATION OF HYPERFINE INTERACTIONS IN METALLIC PRASEODYMIUM AND THULIUM. Holmstroem, B.; Anderson, A. C.; Krusius, M. (Technical Univ. of Helsinki, Otaniemi, Finland). Phys. Rev.; 188: 888-92(10 Dec 1969).

The nuclear specific heat due to hyperfine interactions was measured for the rare-earth metals Pr and Tm in the temperature range 0.02 to 0.4°K. The results for Pr strongly support the suggestion that the electronic magnetic moments are ordered on only half the sites of the double-hcp lattice, and that this order is sinusoidally modulated in space. The maximum value of the electronic moment is 0.95 $\mu_B$, as compared with the free-ion moment of 3.2 $\mu_B$. The maximum hyperfine splittings are $+0.0624 \pm 0.0008$ and $-0.0032 \pm 0.0002$ K for the magnetic dipolar and the electric quadrupolar interactions, respectively. The data for Tm are indicative of a magnetic hyperfine splitting of $-0.1072 \pm 0.0008$ K, which is 5% less than expected for the fully saturated electronic moment. (auth)

**15412** NEUTRON-DIFFRACTION STUDY OF MAGNETIC ORDERING IN $UP_{0.75}S_{0.25}$. Lander, G. H. (Argonne National Lab., Ill.); Kuznietz, Moshe; Cox, D. E. Phys. Rev.; 188: 963-6(10 Dec 1969).

The magnetic ordering of $UP_{0.75}S_{0.25}$, which has the NaCl-type structure, has been determined by powder neutron-diffraction techniques. The initial ordering at about 100°K is ferromagnetic. At around 70°K, a ferrimagnetic structure appears in which ferromagnetic (001) sheets are directed along the c axis in the sequence 5+, 4−, 5+, 4−, .... This corresponds to a ferrimagnetic antiphase type of structure in which the period of modulation is 4.5c and which closely resembles the low-temperature structure of thulium. The ordered moment in this structure is about 1.4 $\mu_B$ per uranium atom, and the net spontaneous moment is 0.16 $\mu_B$, which is in agreement with magnetization measurements. Below about 20°K, a further transition occurs, resulting in the type-IA antiferromagnetic structure, in which the sheets are stacked in the sequence 2+, 2−, 2+, 2−, ... with an ordered moment of $1.7 \pm 0.05$ $\mu_B$. The magnetic ordering in this material, which is a good conductor of electricity, provides strong evidence that long-range oscillatory interactions of Ruderman–Kittel–Kasuya–Yosida (RKKY) type between localized moments are important in actinide materials. (auth)

**15413** ISOTOPE EFFECT FOR THE DIFFUSION OF CADMIUM IN LEAD. Miller, J. Wesley; Edelstein, William A. (Harvard Univ., Cambridge, Mass.). Phys. Rev.; 188: 1081-8(15 Dec 1969).

This experiment to determine the isotope effect for diffusion of $^{109}Cd$ and $^{115m}Cd$ in pure lead was performed as a critical test of the proposed interstitial–vacancy pair mechanism of solute diffusion. The relative diffusivity of the two radioisotopes was determined, after sectioning, by counting with a thin NaI detector system, using energy discrimination. Stability and reproducibility of the count rates were tested and verified, an upper limit on the effect of crossover shown to be negligible, and a zero-isotope-effect experiment performed successfully. The isotope effect for the volume diffusion of cadmium in lead was determined to be $(D_{109}/D_{115m} - 1) = 0.0032 \pm 0.001$ at 248°C, corresponding to a solute correlation factor $f = 0.12$ for a mechanism involving single atomic jumps. It is then shown that this result, together with previous results for the solute and self-diffusivities and $D_I^0$ and $D_I^0$ and the linear-enhancement factor $b_{II}$ for self-diffusion, are inconsistent with the simple vacancy, interstitial, interchange, and ring mechanisms of solute diffusion, but agree with predictions of the model for solute diffusion by means of interstitial solute–vacancy pairs. The migration of associated vacancies results in a strong correlation of successive atomic jumps of bound interstitial solute atoms. (auth)

**15414** ELECTRONIC AND MAGNETIC STRUCTURE OF $SmB_6$. Cohen, R. L.; Eibschuetz, M.; West, K. W. (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev. Lett.; 24: 383-6(23 Feb 1970).

A new electronic configuration involving localized 6s electrons is hypothesized for the Sm ions in $SmB_6$. The model is successful in explaining earlier results of susceptibility measurements and new Mössbauer spectroscopy data reported here.

**15415** THE EFFECT OF DIFFERENT EXCHANGE APPROXIMATIONS ON A PSEUDOPOTENTIAL CALCULATION OF PHONON DISPERSION RELATIONS IN BERYLLIUM. King, W. F. (Technical Univ., Lyngby, Denmark); Cutler, P. H. Phys. Lett.; 31A: 150-1(9 Feb 1970).

A comparison is made of the Slater, Kohn–Sham, and Hartree–Fock approximations for exchange used in a first-principle pseudopotential calculation of the photon dispersion relations in beryllium. (auth)

**15416** ANOMALOUS BEHAVIOR OF THE ELECTRICAL RESISTIVITY IN THE COMPOUND $Ce_3Al_{11}$. Van Daal, H. J.; Buschow, K. H. J. (Philips Research Labs., Eindhoven, Netherlands). Phys. Lett.; 31A: 103-4(9 Feb 1970).

Electrical and magnetic properties are reported for intermetallic compounds $(Ce_{1-x}La_x)_3Al_{11}$ between 1.3 and 300°K. The occurrence of a minimum at about 20°K in the resistivity is attributed to the Kondo effect. (auth)

**15417** MAGNETIC PROPERTIES OF HYDRIDES OF SEVERAL ELEMENTS OF THE I AND II SUBGROUPS. Rakos, M. (Technical Univ., Kosice, Czech.). Czech. J. Phys.; 20: 140-4(1970).

Magnetic susceptibility and NMR derivative measurements are reported for LiH, $LiAlH_4$, and $NaAlH_4$. The susceptibility data were used to determine the polarization–paramagnetism $\chi_p$. Effects of impurities on the susceptibility and NMR were investigated briefly for NaH, $MgH_2$, $CaH_2$, and KH. (D.L.C.)

## Moessbauer Effects and NMR

*Refer also to abstracts 14299, 14375, 14376, 14379, and 15392.*

**15418** (IS-T-323) NUCLEAR MAGNETIC RESONANCE IN TRANSITION METAL BORIDES. Creel, Roger Bryan (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 194p. Dep. CFSTI.

Thesis.

The environment of the boron nucleus in the transition metal borides was studied, utilizing the methods of nuclear magnetic resonance (nmr). The electric field gradient (EFG) parameters at the boron site were measured in several monoborides by analysis of the $^{11}B$ nmr spectra. This analysis was facilitated by comparison of the experimental traces with synthetic derivative line shapes generated by a computer. The experimental values of both $\eta$ and $\nu_Q$ are an order of magnitude smaller than predicted on the basis of strong covalent bonding between neighboring boron atoms. The temperature dependence of the $^{11}B$ nmr signal was used to determine the Néel temperature of $CrB_2$. The nmr signal vanishes without shifting or broadening as the Néel temperature is approached, which indicates the antiferromagnetic ordering is without local moment, as in pure Cr. The analysis yields a Néel temperature of $T_N = 88.0 \pm 2.0$°K. The temperature dependence of the $^{11}B$ line width was used to determine the paramagnetic Curie temperature in $MnB_2$. The observation of the $^{11}B$ signal above the

Curie temperature, but below the Néel temperature, is the first example of the observation of conventional nmr in an antiferromagnet. The $^{11}B$ nuclear spin–lattice relaxation rates were measured in several of the transition metal diborides. The spin-½ tone-burst theory was extended to apply to the spin-3/2 case in the presence of a quadrupole interaction. It was found that the measured relaxation rates could be explained on the basis of a dominant core polarization relaxation mechanism. (auth)

**15419** STANDARD FLUCTUATIONS IN POINTS RECORDED FUNCTIONS. Aramu, F.; Maxia, V. (Univ., Cagliari, Italy). Nucl. Instrum. Methods; 77: 320-4(1970).

An equation is given which enables one to evaluate the statistical fluctuations when a function is determined by means of several experimental points. This equation is analogous to the well-known formula of standard deviations, and is deduced from a distribution that substantially is a generalization of the Γ distribution. An explanatory application is made using a Moessbauer resonant-absorption spectrum recorded by a multichannel analyzer. (auth)

**15420** INFLUENCE OF SIMULTANEOUS STATIC AND TIME-DEPENDENT QUADRUPOLE INTERACTIONS ON γ–γ ANGULAR CORRELATIONS. Andrade, P. da R.; Rogers, J. D.; Vasquez, A. (Univ. Federal do Rio Grande do Sul, Porto Alegre, Brazil). Phys. Rev.; 188: 571-5(10 Dec 1969).

The form of the perturbation factors is derived for the angular correlation of two successive γ rays when the intermediate state is under the influence of an axially symmetric static electric field gradient plus a small randomly fluctuating quadrupole perturbation. The Bloch–Wangness–Redfield theory of nuclear relaxation is applied to calculate the evolution of the density matrix, and the form of the perturbation factors is calculated for several special cases in single-crystal and powder sources. (auth)

**15421** DIRECT OBSERVATION OF THE INTERFERENCE BETWEEN INTERNAL CONVERSION AND PHOTOEFFECT IN $^{161}Dy$. Lukashevich, I. I.; Gorobchenko, V. D.; Sklyarevskii, V. V.; Filippov, N. I. (Academy of Sciences, Moscow). Phys. Lett.; 31A: 112-13(9 Feb 1970).

An energy dependence of the cross section for creation of conversion electrons during the resonant absorption of gamma rays by $^{161}Dy$ nuclei in metallic dysprosium was investigated. The asymmetry of the Moessbauer line shape observed in experiment is connected with the presence of an interference between processes of photoeffect and internal conversion. (auth)

**15422** THEORY OF THE MOESSBAUER EFFECT IN SUBSTANCES WITH MAGNETIC ORDER. Grigor'ev, M. L. (Inst. of Physics of Metals, Moscow). Fiz. Metal. Metalloved.; 28: 401-10(Sep 1969). (In Russian).

The main goal of the work is the calculation of γ-ray absorption coefficients of Moessbauer nuclei in crystals with magnetic order. A new approach to the problem, the basis of which is the utilization of the single quasi-nucleon model of nuclei with odd mass number (most Moessbauer nuclei are of this type). Results agree with those found previously by Kagan and Afranas'ev using another method (Zh. Eksp. Teoret. Fiz., 47: 1108(1964)). (tr-auth)

### Theory

**15423** YADERNYI AKUSTICHESKII REZONANS. (Nuclear Acoustic Resonance). Kessel, A. R. Moscow; Izdatel'stvo Nauka (1969). 216p.

Theoretical and experimental data on nuclear acoustic resonance are discussed. Theoretical principles are reviewed in the first chapter. Acoustic saturation of nuclear spin systems, excitation of transitional processes in nuclear spin systems with acoustic pulses, and quantum statistical theory of acoustic resonance are discussed in the next three chapters. Experimental methods of nuclear acoustic resonance and their applications are covered in the last two chapters. (R.V.J.)

## Theoretical Physics

*Refer also to abstracts 15432, 15615, and 15636.*

**15424** ANGLE AND PHASE COORDINATES IN QUANTUM MECHANICS. Zak, J. (Northwestern Univ., Evanston, Ill.). Phys. Rev.; 187: 1803-10(25 Nov 1969).

A general approach to the description of an angle and phase is given on the basis of the kq representation. It is shown that an angular coordinate in quantum mechanics has to be treated as a quasicoordinate in order to avoid inconsistencies. The kq representation leads to a consistent definition of the angular-momentum–angle degree of freedom. Using the correspondence between classical and quantum mechanics for the phase of a harmonic oscillator, operators are defined that form a new quantum-mechanical representation. This representation clarifies the concept of the phase and sheds light on the general understanding of rotations in quantum mechanics. (auth)

**15425** NONUNIQUENESS OF THE SPIN-½ EQUATION. Capri, Anton Z. (Univ. of Alberta, Edmonton). Phys. Rev.; 187: 1811-15(25 Nov 1969).

It is shown that the Dirac equation is not the only first-order differential equation that is form-invariant under Lorentz transformations, irreducible, and derivable from a Lagrangian, and whose solutions correspond to mass m and spin ½. It is, however, the only such equation, except for spin 0 and 1, for which $\beta_0$ is diagonalizable. (auth)

**15426** PROPER TIME AND LOCALIZATION FOR THE QUANTUM RELATIVISTIC ELECTRON. Kalnay, Andres J.; Cotrina, Enrique Mac (Univ. Nacional de Ingenieria, Lima). Progr. Theor. Phys. (Kyoto); 42: 1422-44(Dec 1969).

A satisfactory proper time operator is found for Dirac's quantum relativistic electrons. A self-consistent scheme is developed in which this operator and Beck's proper time derivative have the properties they should have. As an application of the proper time formalism as a research tool, properties of three position operators (which are generally considered as covariant) are studied in regard to their behavior under the inhomogeneous Lorentz group and under ordinary and proper time evolution. They are Pryce's class d, Bacry's and R. J. Finkelstein's operators. It results that all three have some unreasonable properties for Dirac's electron. The reason for the difficulty in the case of Finkelstein's operator can be traced back to an incorrect definition of it. By making some changes a satisfactory position operator is obtained but it turns out to be equivalent to Bunge's (up to an arbitrary and unimportant constant of motion). The results of this paper reinforce those of previous work which show that (for Dirac's electron) Bunge's position operator seems to be in a privileged place as regards the solution of the localization problem. Incidentally, the interpretation of some relations previously used as auxiliary formulas for computations allows a manifestly covariant expression for Dirac's Hamiltonian and a second manifestly covariant form of Dirac's equation to be obtained. (auth)

**15427** COVARIANT POSITION OPERATOR FOR THE RELATIVISTIC ELECTRON. Bunge, Mario; Kalnay, Andres J. (McGill Univ., Montreal. Univ. Nacional de Ingenieria, Lima). Progr. Theor. Phys. (Kyoto); 42: 1445-59(Dec 1969).

The properties of a position operator previously introduced by one of the authors (Bunge, 1955) are investigated in more detail. A formalism is worked out that is consistent with formal manifest covariance and has a close classical analog. The results are discussed in connection with the electron structure and the zitterbewegung. (auth)

**15428** POSITRON EFFECTIVE MASS IN AN ELECTRON GAS. Bergersen, Birger; Pajanne, Erkki (Inst. of Theoretical Physics, Goteborg). Phys. Rev.; 186: 375-80(10 Oct 1969).

The positron effective mass in an electron gas at the sodium electron density is calculated, emphasizing terms which are nonlinear in the electron–positron interaction. A close similarity between the perturbation expansions for the lifetime and the self-energy is exploited. Both quantities are approximated by a t-matrix equation, using a two-parameter static effective interaction. The parameters are restricted to values that give agreement with the experimental annihilation rate. It is shown to be possible to obtain agreement with the experimental effective-mass value calculated from the thermal smearing of the 2γ angular correlation by Stewart and co-workers. However, if, in addition, we impose the screening requirement that the total displaced electron charge should exactly compensate the positron charge, we obtain effective-mass values that are too low. This result indicates that the observed thermal smearing of the angular-correlation curves cannot be explained from the effective mass of positrons in an electron gas. (auth)

**15429** PRODUCT OF FIELD OPERATORS AND FINITE FIELD EQUATIONS. Nishijima, Kazuhiko; Sato, Hikaru (Tokyo Univ.). Progr. Theor. Phys. (Kyoto); 42: 1460-7(Dec 1969).

A derivation of finite field equations is proposed by analyzing the singularity structure of the product of two field operators at the same space–time point. Also discussed is the question of how to incorporate commutation relations with field equations. (auth)

**15430** THEORY OF DISORDERED FOUR-COMPONENT SYSTEMS. Tahir-Kheli, Raza A.; Taggart, G. Bruce (Temple Univ., Philadelphia). Progr. Theor. Phys. (Kyoto); 42: 1265-83 (Dec 1969).

A formulation of the statistical correlations in four-component systems, with arbitrary composition and pairwise interatomic potentials of arbitrary range, is given. Exact formal expressions for the relevant short range order (SRO) parameters are derived. A procedure for consistently calculating the high temperature series expansions for the SRO parameters is given and the linear approximation, valid at elevated temperature, is worked out in detail. The linear results for the inverse lattice Fourier transforms of the SRO parameters are represented in a form analogous to the results of self-consistent mean field theories. The usefulness of such a representation lies in its qualitative validity even in the vicinity of the order-disorder transition point. The transition temperature is estimated through the singularity of the temperature derivative of the correlation parameters. The relevance of the given expression for the SRO for inferring possible ground state orderings, i.e., the actual spatial configurations that might obtain when the ordering sets in, is indicated. In the limit that the atomic composition of one of the four constituents approaches zero, our results smoothly reduce to the previously derived linear results for ternary systems.

**15431** NONCLASSICAL GENERAL COVARIANCE AND COMPLEMENTARITY. II. Tangherlini, F. R. (Coll. of the Holy Cross, Worcester, Mass.). Lett. Nuovo Cim.; 3: 88-92(15 Jan 1970).

It was previously shown that general covariance extended to the nonclassical domain led to the commuting of the space-time operators. The same argument applied to canonical transformations led to the noncomplementarity of the coordinates and the momenta. The original argument is revised, and it is found that the canonical transformations because of canonical restrictions on the transformations permit the commutation relations to be preserved for the complementary quantities; while, because of the arbitrariness of point transformations, the commutation relations for coordinates can only be preserved provided the coordinates commute with each other. The basic result is unchanged, that nonclassical general convariance leads to noncomplementarity. (L.B.S.)

**15432** S-MATRIX PROBLEMS (QUASICLASSICS). Kolkunov, V. A. (Inst. of Theoretical and Experimental Physics, Moscow). Yadern. Fiz.; 10: 1296-1303(1969). (In Russian).

The S matrix for the Schroedinger one-dimensional equation represented in form of the multiplicative integral is expressed as a sum of infinitely small intervals on the Lobatschevsky plane — transition amplitudes between the passing wave and the reflected wave. The Planck constant plays the role attribute to the velocity of light in the special relativity. The transition from the classical mechanics to the quantum theory is equivalent to the transition from the Euclidean geometry to the Lobatschevsky geometry. It is shown that the series obtained as the expansion of the S matrix in the quasiclassical case $\hbar \to 0$ is absolutely convergent. (auth)

**15433** THREE-BODY PROBLEM. TOTAL SET OF ORTHOGONAL ANGULAR FUNCTIONS. Pustovalov, V. V.; Smorodinskii, Ya. A. (Inst. of Atomic Energy, Moscow). Yadern. Fiz.; 10: 1287-95(1969). (In Russian).

Angular functions with all the five quantum numbers $K^2$, $L^2$, M, $\nu$, and $\Omega$, are constructed. The functions are parametrized in the coordinate system that is invariant under any perturbations. (auth)

**15434** QUANTUM PROBABILITY WEIGHTED PATHS. Gilson, J. G. (Queen Mary Coll., London). Acta Phys. Acad. Sci. Hung.; 26: 319-33(1969).

A generalization of Feynman's method is discussed. A real "probability" measure is introduced for weighting trajectories and this is expressed as the boundary case of a measure containing one real parameter. For the finite values of the real parameter an equation of motion of the Fokker–Planck type is used. In the zero boundary case a Schroedinger equation is derived. A simple deduction is given for the Wigner phase space distribution by using the differentiability of quantum trajectories, which is also proved. It is suggested that the equation of motion obtained for the finite values of the real parameter included in the theory describe real processes. (auth)

**15435** CANONICAL TRANSFORMATION IN CLASSICAL AND QUANTUM MECHANICS. Fock, V. (Leningrad State Univ.). Acta Phys. Acad. Sci. Hung.; 27: 219-24(1969).

A more exact formulation for Dirac's proposition on the analogy between the unitary transformations in quantum theory and the contact transformations in classical theory is given. It is shown that approximate expressions for the matrix elements of the unitary operator defining the transformation can be constructed in terms of classical quantities. One can thus speak not only of an analogy between unitary and contact transformations, but also of an approximate equality between the quantum mechanical and semi-classical expressions for the corresponding quantities. (auth)

**15436** ELECTRODYNAMIC PROCESSES: PHYSICAL MEANING AND MATHEMATICAL DESCRIPTION. Braffort, Paul (European Space Research Organization, Domeinweg, Netherlands). Compt. Rend., Ser. B; 270: 12-14(5 Jan 1970). (In French).

Stochastic processes describing the interactions of systems of elementary charges are briefly analyzed. The analysis, from the point of view of either Langevin or Kramer, shows that processes belonging to the family do not have the Markov character and, therefore, establishes the incompatibility between two conjectures related to the foundations of quantum theories. (France)

**15437** MOTION OF A CHARGED PARTICLE IN ELECTRIC AND MAGNETIC FIELDS. Chang, F. C.; Audeh, N. F. (Univ. of Alabama, Huntsville). Proc. IEEE (Inst. Elec. Electron. Eng.); 58: 145-6(Jan 1970).

The motion of a charged particle in time-varying uniform electric and magnetic fields was determined exactly by writing the Lorentz force equation in a matrix form. The general solution is obtained by solving the ordinary first-order linear differential equation. (auth)

**15438** ON THE INVERSION OF NOETHER'S THEOREM IN THE LAGRANGIAN FORMALISM. Palmieri, C. (Univ., Naples); Vitale, B. Nuovo Cim.; 66A: 299-312(1 Mar 1970).

A generalized form of Noether's theorem is discussed, relating conserved quantities to infinitesimal transformations that do not leave necessarily invariant the Lagrangian function of a dynamical system. Necessary and sufficient conditions on the constants of motion for their being related to actual invariance of the Lagrangian are derived. (auth)

**15439** POSITRON EFFECTIVE MASS IN AN ELECTRON GAS. Garg, J. C.; Saraf, B. L. (Univ. of Rajasthan, Jaipur, India). Phys. Lett.; 31A: 144-5(9 Feb 1970).

The effective mass of positron in an electron gas is calculated on the basis of electron charge distribution as modified by positron–electron correlations. It is shown that it is possible to obtain agreement with experimental results without violating the charge sum rule. (auth)

**15440** CHARGE AND POLE: CANONICAL COORDINATES WITHOUT POTENTIALS. Kerner, Edward H. (Univ. of Delaware, Newark). J. Math. Phys. (N. Y.); 11: 39-46(Jan 1970).

For particles having both magnetic and electric charge it is shown that (a) in the nonrelativistic many-particle problem where only Coulomb and Biot–Savart fields need be considered and (b) in the one-particle relativistic problem (orbital pole–charge moving around a fixed pole–charge), the well-set classical dynamics can be reduced directly from the equations of motion to Hamiltonian form without the introduction of potentials and Dirac strings. The Lie–Koenigs theorem, which can give Hamiltonian format to any dynamics, is invoked for this. The essential feature is that canonical coordinates cannot be physical particle coordinates. For (a) and (b), suitable canonical variables are explicitly constructed. Using only Bohr–Sommerfeld quantization, the Schwinger charge–pole quantum condition is obtained for pure-charge–pure-pole interactions; but when Coulomb forces are additionally considered, no quantum restriction on charge and pole strength is required. (auth)

**15441** QUANTIZATION OF A SYSTEM OF FREE PARTICLES IN THE HYPERSPHERICAL FORMALISM. Fabre de la Ripelle, Michel (Paris Univ., Orsay, France). Compt. Rend., Ser. B; 270: 9-11(5 Jan 1970). (In French).

A method of quantization of a free particle system in the hyperspherical formalism is presented. The constraint consists in imposing the reduction to zero of the system eigenfunction on the surface of a hypersphere of radius R, which, in the ordinary space, comes to limit the sum of the squares of the distances between particles and their center of mass. The sequence and the degeneracy of the system levels are deduced from the properties of Bessel function zeros and from the degeneracy of hyperspherical angular eigenfunctions. (auth) (France)

# PHYSICS (HIGH ENERGY)

## Particle Interactions and Properties (Experimental)

**15442** (CERN-69-28, pp 141-4) SEARCH FOR LOW ENERGY MUONS PRODUCED DIRECTLY BY NEUTRAL COSMIC RAYS. Ashton, F.; Edwards, H. J.; Kelly, G. N. (Durham Univ. (England). Dept. of Physics).

The interaction of neutral cosmic particles with protons, producing a neutron and a low-energy muon is studied using scintillator and Cherenkov counters. (J.F.P.)

**15443** A SEARCH FOR $SU_3$ PARTICLES IN EAS AT 3500 m s.l. Bosia, G.; Briatore, L. (CNR, Turin. Univ., Turin). Nuovo Cim.; 66A: 167-84(1 Mar 1970).

A search for massive fractionally charged particles both single and in EAS has been performed at Plateau Rosa, 3500 m s.l., using a scintillation counter telescope correlated with an EAS array by means of a fast coincidence-anticoincidence system allowing charge and delay measurements. For unaccompanied particles the upper limits $I_q(\pm e/3) \leq (5.0 \pm 3.5) \cdot 10^{-10}$ cm$^{-2}$ sr$^{-1}$ s$^{-1}$ and $I_q(\pm 2e/3) \leq (2.5 \pm 2.5) \cdot 10^{-10}$ cm$^{-2}$ sr$^{-1}$ s$^{-1}$ for fluxes were obtained, and for particles in EAS $J_q(\pm e/3) = J_q(\pm 2e/3) \leq 6.2 \cdot 10^{-10}$ cm$^{-2}$ sr$^{-1}$ s$^{-1}$ with 90% confidence level. The detection efficiency in charge and delay in the two cases is discussed with some calculations. (auth)

### Electromagnetic

*Refer also to abstract 15788.*

**15444** (ORNL-tr-2257) EXPERIMENTAL INVESTIGATION OF THE PROCESS OF ELECTRON-PHOTON SHOWER GENERATION AT ENERGIES RANGING FROM 20 TO 300 MeV. Ogrzevalskii, Z.; Strugal'skii, Z. S. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated for Oak Ridge National Lab., Tenn., from report JINR-P1-4562. 15p. Dep. CFSTI.

This article was previously abstracted from the original language and appeared in NSA as 23: 51830. (C.E.S.)

**15445** PHOTOPRODUCTION OF 8-GeV RHO MESONS FROM NUCLEI. Behrend, H. J.; Lobkowicz, F.; Thorndike, E. H.; Wehmann, A. A. (Univ. of Rochester, N. Y.). Phys. Rev. Lett.; 24: 336-40(16 Feb 1970).

Results on measurements of photoproduction of $\rho^0$ mesons from seven different nuclei are presented. The forward cross sections are analyzed in terms of the $\rho$-nucleon total cross section and the $\gamma$-$\rho$ coupling constant, giving $\sigma(\rho,N) = 26.8 \pm 2.4$ mb and $\gamma_\rho^2/4\pi = 0.62 \pm 0.12$. (auth)

**15446** ANALYSIS OF THE REACTION $e^+ + e^- \rightarrow \pi^+ + \pi^-$ AND HARD-PION CURRENT ALGEBRA. Vaughn, M. T. (Northeastern Univ., Boston). Lett. Nuovo Cim.; 2: 851-5(21 Dec 1969).

A phenomenological procedure is given for analyzing data from the $e^+ + e^- \rightarrow \pi^+ + \pi^-$ colliding-beam reaction, incorporating $\rho$-dominance and the analyticity of the pion electromagnetic form factor $F_\pi(t)$ for timelike t, and results of hard-pion current algebra. The data from Novosibirsk and Orsay are analyzed. (L.B.S.)

**15447** PHOTOPRODUCTION OF POSITIVE PIONS ON HYDROGEN AT PHOTON ENERGIES BETWEEN 220 AND 425 MeV. Fischer, G.; Fischer, H.; Heuel, M.; von Holtey, G.; Knop, G.; Stumpfig, J. (Univ., Bonn). Nucl. Phys.; B16: 119-24(1970).

Differential cross sections for $\pi^+$ photoproduction on hydrogen were measured over a photon energy range from 220 to 425 MeV and for point cm angles between 15° and 70°. The pions were analyzed in angle and momentum by a magnetic spectrometer. (auth)

**15448** PHOTOPRODUCTION OF NEUTRAL PIONS ON HYDROGEN AT PHOTON ENERGIES BETWEEN 200 AND 440 MeV. Fischer, G.; Fischer, H.; Von Holtey, G.; Kaempgen, H.; Knop, G.; Schulz, P.; Wessels, H.; Braunschweig, W.; Genzel, H.; Wedemeyer, R. (Univ., Bonn). Nucl. Phys.; B16: 93-101(1970).

Differential cross sections for neutral-pion photoproduction on hydrogen in the region of the first resonance were measured by two independent experiments detecting the recoil protons. The results of both measurements were combined into one set of cross sections covering the photon energy range from 200 to 440 MeV at pion cm angles between 50 and 160°. (auth)

**15449** ANALYSIS OF THE ELECTRON COMPONENT FROM MUON INTERACTIONS UNDERGROUND. Chaudhuri, N.; Goswami, B. (Univ. of North Bengal, Darjeeling, India). Nuovo Cim.; 65A: 727-37(21 Feb 1970).

The final results of the analysis of electron component generated by high-energy muons in iron plates of a cloud chamber are given. The information obtained is as follows: (1) The frequency of single electrons (knock-ons) observed for two different target thicknesses is in excellent agreement with theory for energy transfer up to 1 GeV. Above 1 GeV, there is some indication of discrepancy. (2) The frequency of events in each of which two or more electrons are produced (mostly trident pairs) is in satisfactory agreement with theory for energy transfer up to the region of 1 GeV. (3) The differential energy spectrum of single electrons is found to be represented by $E'^{-n}$ with $n = 2.06 \pm 0.15$. The integral spectrum is also drawn and the spectra are compared with those predicted by theory. (4) The projected angular distribution of single electrons is found to be represented by a simple cosine power law with the values of exponent $2.97 \pm 0.01$ and $2.51 \pm 0.00$ for thickness 0.3 and 0.9 rad units of iron, respectively. (auth)

**15450** A NEW MEASUREMENT OF THE $\pi^0$ LIFETIME THROUGH THE PRIMAKOFF EFFECT IN NUCLEI. Bellettini, G. (Univ., Pisa, Italy. Istituto Nazionale di Fisica Nucleare, Pisa, Italy. Scuola Normale Superiore, Pisa, Italy); Bemporad, C.; Braccini, P. L.; Bradaschia, C.; Foa, L.; Luebelsmeyer, K.; Schmitz, D. Nuovo Cim.; 66A: 243-52(1 Mar 1970).

A new measurement of the $\pi^0$ lifetime through the Primakoff effect on nuclei was performed at DESY. The $\pi^0$ photoproduction at small angles was measured on four elements (C, Zn, Ag, Pb) at two energies (1.5 GeV and 2.0 GeV). The final result for the lifetime is $\tau = (0.56 \pm 0.06) \cdot 10^{-16}$ s. (auth)

### Weak

*Refer also to abstracts 15707–15710.*

**15451** (AEC-tr-6882/2) 12th INTERNATIONAL CONFERENCE ON HIGH-ENERGY PHYSICS, DUBNA, 1964. VOLUME 2. Smorodinskii, Ya. A. (ed.). Translation of XII Mezhdunarodnaya Konferentsiya po Fizike Vysokikh Energii, Dubna, 1964. 594p. (TT-68-50325/2; CONF-550-(Vol.2); IPST-Cat-5131). Dep. CFSTI.

The topics covered are experimental neutrino physics, experimental weak interactions of nonstrange particles and strange particles, and theoretical weak interactions, developments in methods using spark and luminescent chambers and counters. Also data processing systems for physical experiments, bubble chamber techniques, and methods of production and separation of high-energy particle beams are discussed. For abstracts of individual papers from this conference see CONF-550 in a cumulative report number index. (J.F.P.)

*For abstracts of individual papers see: 15442, 15453–15459, 15528, and 15706–15712.*

**15452** (CERN-69-28) NEUTRINO MEETING, CERN, GENEVA, 13-14 JANUARY 1969. Proceedings. Pattison, J. B. M.; Ramm, C. A.; Venus, W. A. (eds.) (European Organization for Nuclear Research, Geneva (Switzerland)). 10 Nov 1969. 173p. (CONF-690121). CERN.

The conference included 16 papers. Separate abstracts were prepared for each paper. (J.F.P.)

**15453** (CERN-69-28, pp 3-12) PLANS FOR NEUTRINO EXPERIMENTS WITH THE 12 FT BUBBLE CHAMBER AT THE ZGS. Derrick, M. (Argonne National Lab., Ill.).

The development of a 12-foot hydrogen bubble chamber for neutrino experiments at the 12.5-GeV ZGS is described. The design and status of the chamber, the neutrino beam, flux determination and the neutrino spectrum and event rates are considered. Also the expected results are discussed. (J.F.P.)

**15454** (CERN-69-28, pp 81-93) PROGRESS REPORT ON THE KOLAR GOLD FIELD NEUTRINO EXPERIMENT. Krishnaswamy, S.; Menon, M. G. K.; Narasimham, V. S. (Tata Inst. of Fundamental Research, Bombay (India); Ito, N.; Kino, S.; Miyake, S. (Osaka City Univ. (Japan)); Craig, R.; Wolfendale, A. W. (Durham Univ. (England)).

The latest results on the interactions of cosmic ray muon neutrinos underground in the experiments in the Kolar Gold Fields are presented. Unambiguous examples of upward moving muon secondaries are reported and measurements made on the momenta of some of the secondaries are described. The observation of a

comparatively high frequency of multiple particle events points to the importance of inelastic neutrino interactions. (auth)

**15455** (CERN–69–28, pp 95–101) COSMIC RAY MUON NEUTRINO INTENSITIES BELOW 1 GeV. Wolfendale, A. W. (Durham Univ. (England)); Young, E. C. M. (Hong Kong Univ.).

The observation of stopping muons deep underground, thought to be due to neutrino interactions, has drawn attention to the need to calculate muon neutrino spectra below 1 GeV. The results of preliminary calculations are given here, together with a very approximate calculation of the expected energy spectrum of neutrino-induced muons below 1 GeV. Application to the results of the Case-Wits Experiment suggest that the observed frequency is of the order of magnitude expected. (auth)

**15456** (CERN–69–28, pp 103–10) INFORMAL STATUS REPORT ON CASE–WITS–IRVINE COSMIC RAY NEUTRINO EXPERIMENT. Reines, F. (California Univ., Irvine).

A two-mile deep underground cosmic-ray neutrino experiment is described. A scintillation hodoscope is used to detect the neutrinos. Some 379 events of all kinds were observed, and of these events there were 342 due to cosmic rays and 37 due to neutrinos. (J.F.P.)

**15457** (CERN–69–28, pp 111–24) QUASI-ELASTIC NEUTRINO SCATTERING. Kustom, R. L.; Lundquist, D. E.; Novey, T. B.; Yokosawa, A. (Argonne National Lab., Ill.); Chilton, F. (Stanford Research Inst., Menlo Park, Calif.).

Quasi-elastic scattering of neutrinos, $\nu + n \rightarrow p^+ + \mu^-$, was measured in a 30 ton spark chamber detector. Analysis of the cross section versus momentum transfer yields a value of $M_{A_1} = 0.7 \pm .15$ for a single pole type axial-vector form factor or $M_{A_2} = 1.05 \pm .2$ for a double pole form factor. No decrease in cross section at low momentum transfer expected due to nuclear effects was observed. (auth)

**15458** (CERN–69–28, pp 125–40) PRODUCTION OF LOW-ENERGY MUONS AT SEA-LEVEL BY NEUTRAL COMPONENTS IN THE COSMIC RADIATION. Cowan, C. L.; Hesse, P. W.; Johnston, R. L.; Maciorowski, F. L.; O'Sullivan, C. T.; Shelby, R. N.; Talbott, F. L. (Catholic Univ. of America, Washington, D. C. Dept. of Physics).

The results of an additional analysis of some previous and new data on low-energy meson ($\mu$) production from neutral cosmic particles collected following several modifications to the spark chamber telescope are presented. (J.F.P.)

**15459** (CERN–69–28, pp 145–58) BACKGROUND PROBLEMS IN A BUBBLE CHAMBER NEUTRINO EXPERIMENT. Myatt, G. (European Organization for Nuclear Research, Geneva (Switzerland)).

The background in a bubble chamber neutrino experiment for the study of $\nu_\mu + N \rightarrow \mu^- + N'$ interactions is discussed. This discussion covers incoming pion and neutron interactions, the antineutrino background, and $\nu_e$ interactions. (J.F.P.)

**15460** (TID–25338) BUBBLE CHAMBER GROUP PROGRESS REPORT, JANUARY 1, 1969–DECEMBER 31, 1969. (State Univ. of New York, Stony Brook. Dept. of Physics). Contract AT(30-1)-3668. 62p. Dep. CFSTI.

The Stony Brook Bubble Chamber Group in the preceding year (its fourth year of operations) has continued its investigations of hyperon leptonic decays, resulting in a determination of the $G_V/G_A$ value for the $\Lambda$ hyperon $\beta$-decay; the $G_V/G_A$ value for the $\Sigma$ hyperon $\beta$-decay; and the partial decay rate of the $\Sigma$ hyperon into muon, neutron and neutrino. The last two were done in collaboration with the Columbia University Bubble Chamber Group. Two other experiments are also in progress. First, an optical spark chamber experiment was run at the Princeton-Pennsylvania Accelerator in the spring of 1969 as a joint Stony Brook-Columbia effort to determine the branching ratio $Ks \rightarrow \pi^+ + \pi^-/Ks \rightarrow \pi^0 + \pi^0$. For this experiment, at Stony Brook, all the $\Lambda$ event candidates in the film resulting from the associated production $\pi^- + p \rightarrow \Lambda^0 + K^0$ were extracted. This will lead to a result in the aforementioned branching ratio in the next year. Secondly, we obtained kinematical data on four-prong topology events from 20,000 pictures of an exposure at 9 GeV/c $K^-$ in the 80'' BNL Hydrogen Bubble Chamber, for the purpose of studying high energy inelastic scattering phenomena. The above mentioned experiments involved the measurement of over 136,000 events on the IPD's (Image-Plane-Digitizers) and about 9,000 events on precision machines. This rather extraordinary rate of measurement production was accomplished by both innovations in software control over the machines and meticulous maintenance of the rather delicate and elaborate equipment. (auth)

**15461** (UCSD–10–P–10–107) A TEST OF THE $\Delta S = \Delta Q$ RULE IN NEUTRAL K–e3 DECAY. Littenberg, Laurence Stephen (California Univ., La Jolla, San Diego). Dec 1969. Contract AT(11-1)-Gen-10. 167p. Dep. CFSTI.

Thesis.

Neutral K–e3 decay in the $K^0-\overline{K}^0$ interference region was studied. $K^0$'s were produced by the charge exchange of a 1 GeV/c separated $K^+$ beam. The three charge exchange targets were separated by spark chambers to allow determination of the charge exchange point. The K's decayed in a thin foil spark chamber situated in a magnetic field. Electrons were identified by their showers in a 12 gap spark chamber with $\frac{1}{8}$ inch lead plates between the gaps. One and three tenths million pictures were scanned to obtain ~40,000 leptonic candidates from which 686 events were selected. The lifetime distributions of the selected $e^+\pi^-\overline{\nu}$ and $e^-\pi^+\nu$ events were fit to the theoretical distributions and the ratio of $\Delta S = -\Delta Q$ amplitude to the $\Delta S = \Delta Q$ amplitude was found. (auth)

**15462** NON-MESONIC DECAY OF HELIUM HYPERNUCLEI. Coremans, G. (Univ. Libre, Brussels); Sacton, J.; O'Sullivan, D.; Esmael, F.; Davis, D. H.; Shaukat, M. A.; Pniewski, T.; Allen, J. E. Nucl. Phys.; B16: 209–20(1970).

The analysis is reported of a sample of hypernuclei decaying non-mesonically with the emission of one or two charged particles which were obtained from $K^-$ meson captures at rest in nuclear emulsion. Making use of the decay parameters established for the ${}^4_\Lambda$He hypernucleus from observations in a helium bubble chamber, a value of $Q^-$, the ratio of nonmesonic to $\pi^-$ mesonic decays for ${}^5_\Lambda$He together with the rates of certain decay modes have been determined. (auth)

**15463** EXPERIMENTAL TEST OF THE PARTIALLY CONSERVED AXIAL-VECTOR-CURRENT HYPOTHESIS. Bonetti, S. V. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan); Fiorini, E.; Rollier, M.; (and others). Lett. Nuovo Cim.; 2: 877–80(21 Dec 1969).

Neutrino events observed in the propane-filled HLBC and $\pi^+$ events observed in the propane-filled Ecole Polytechnique HLBC at $\pi^+$ momentum of 0.215 to 1.930 GeV/c were analyzed to test the predictions of the PCAC hypothesis that the differential cross section for $\nu + \alpha \rightarrow \mu^- + \beta$ is proportional to the total cross section for $\pi^+ + \alpha \rightarrow \beta$, where $\alpha$ and $\beta$ are hadronic systems of different masses. (L.B.S.)

**15464** BRANCHING RATIOS FOR THE $\pi^-$ MESONIC DECAYS OF THE HYPERNUCLEI ${}^3_\Lambda$H AND ${}^4_\Lambda$H. Bertrand, D. (Univ. Libre, Brussels); Coremans, G.; Mayeur, C.; Sacton, J.; Vilain, P.; Wilquet, G.; Wickens, J. H.; O'Sullivan, D.; Davis, D. H.; Allen, J. E. Nucl. Phys.; B16: 77–84(1970).

Results are presented concerning the experimental determination, with large statistics, of the branching ratios for the $\pi^-$ mesonic decay of the hypernuclei ${}^3_\Lambda$H and ${}^4_\Lambda$H. The spin assignments $J({}^3_\Lambda H) = {}^1/_2$ and $J({}^4_\Lambda H) = 0$ are confirmed. (auth)

**15465** LIFETIME OF THE ${}^3_\Lambda$H HYPERNUCLEUS. Bohm, G. (Institut fuer Hochenergiephysik, Berlin); Klabuhn, J.; Krecker, U.; (and others). Nucl. Phys.; B16: 46–52(1970).

The mean lifetime of the ${}^3_\Lambda$H hypernucleus has been estimated in nuclear emulsion using the $(\pi^- + {}^1H + {}^2H)$ decays both at rest and in flight. The result, $\tau({}^3_\Lambda H) = (1.28^{+0.3}_{-0.2}) \cdot 10^{-10}$ sec, is significantly lower than another recent experimental value and the theoretical predictions. A possible explanation of the discrepancy with the theoretical predictions is briefly discussed. (auth)

**15466** INVESTIGATION OF THE DECAY $K^+ \rightarrow \pi^+\pi^0\gamma$ IN $\pi^+$-MESON ENERGY REGION $T\pi^+ < 55$ MeV. Mal'tsev, E. I.; Pestova, G. D.; Solodovnikova, Z. V.; (and others) (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 10: 1195–1200(1969). (In Russian).

It is known that search for direct emission of $\gamma$ quanta in decays $K^0_S \rightarrow \pi^+\pi^-\gamma$, $K^0_L \rightarrow \pi^+\pi^-\gamma$ and $K^+ \rightarrow \pi^+\pi^0\gamma$ at $T_{\pi^+} > 55$ MeV have resulted in the estimates for the amplitudes of the direct transitions $A_{direct} < A_{brehms}$. With this fact in view, an attempt is made to investigate the direct transition in the decay $K^+ \rightarrow \pi^+\pi^0\gamma$ at $T_{\pi^+} < 55$ MeV, when the bremsstrahlung tends to zero. Analysis of the results enable one to conclude that under the mentioned conditions no marked effects of the direct transitions are observed either. (auth)

**15467** MEASUREMENT OF $\Lambda$ HYPERON LIFE TIME IN FREON BUBBLE CHAMBER. Demidov, V. S.; Kirillov-Ugryumov, V. G.; Ponosov, A. K.; Protasov, V. P.; Sergeev, F. M.; Sutugin, V. G. Yadern. Fiz.; 10: 1201–3(1969). (In Russian).

The mean life time $\tau_\Lambda = (2.39 \pm 0.10) \cdot 10^{-10}$ sec was measured in a freon bubble chamber on 1059 events of $\Lambda$ hyperon decay. The cross section of interaction of the $\Lambda$ hyperons with nuclei is estimated. On 1385 events of $K^0_1$-meson decay, the life time was found to be $\tau_{K^0_1} = (0.89 \pm 0.03) \cdot 10^{-10}$ sec. (auth)

**15468** SEARCH FOR LOW-ENERGY MUONS BY NEUTRAL COMPONENTS AT 4500 mw.e. Bergamasco, L.; Castagnoli, C.;

Maringelli, M. (Univ., Turin). Lett. Nuovo Cim.; 3: 159-62 (29 Jan 1970).

A search for low-energy muons produced by neutral components of the cosmic radiation is conducted at 4500 MWe with reduced background effects. A liquid scintillator and photomultipliers were used. An upper limit for the value of the incident flux times the cross section per target nucleons is given for a muonlike angular distribution. This value is lower than that previously found. (J.F.P.)

## *Strong (Baryon-Induced)*

*Refer also to abstracts 15775 and 15786.*

**15469** SOME PROBLEMS IN HIGH-ENERGY PHYSICS. Ross, Dennis Kent. Stanford, Calif.; Stanford Univ. (1968). 193p.

Thesis.

Three problems in high energy physics are treated. Absorption in high energy photo-production is derived using a Regge amplitude. It is found that this depends strongly on the square of the four-momentum transfer t, smaller values of $|t|$ giving much less absorption. This behavior differs markedly from that of the Drell peripheral model with a constant absorption factor. The absorption is calculated for s and t values corresponding to energies encountered in a recent SLAC experiment and is seen to reduce the cross section by factors of 1/220 to 1/25 depending on t. Factors of this order are needed to bring experiment and theory into agreement. The high energy asymptotic behavior of the amplitude with absorption is found to differ from the usual Regge behavior. The usual absorption using a Born amplitude is also elaborated and generalized and is compared with recent DESY data. The well-known high energy Regge behavior of the cross section without absorption, $d\sigma/dt = c(t)s^{2\alpha(+t)-2}$, is derived for completeness for all spins. A field theory of electric and magnetic monopoles which are either point or extended particles is constructed, using Mandelstam's path-dependent field quantities specialized to straight-line paths. Restrictions on the paths and form factors which are needed for self-consistency are given. It is found that the Jacobi identity is satisfied and that the path restrictions maintain themselves in time. Schiff's selection principle for quarks, originally derived in ordering quantum mechanics, follows easily and is thus generalized to field theory. A formalism for high energy multiple scattering which is similar to the Glauber approach but which replaces the small-angle approximation by the larger-angle theory of Schiff is presented. This formalism is applied to the scattering of fast protons from $He^4$ with a very simple model, and Glauber's small-angle approximations are shown to be accurate only out to about 6°. A more realistic model using simple harmonic oscillator S-waves for the nuclear wave functions is then shown to fit the recent 1 BeV scattering data of Palevski, et al., quite well even at the maximum which occurs at $q^2 = 9.4$ fm$^2$, where the simple Glauber approach falls short. Using modified nuclear wave functions and the Glauber formalism, Bassel and Wilkin can also fit this maximum. A good fit is obtained by improving the basic scattering theory, rather than by using a small-angle theory at fairly large angles and then modifying the nuclear model. (Diss. Abstr.)

**15470** PARTICLE PRODUCTION AT HIGH TRANSVERSE MOMENTUM IN HIGH-ENERGY PROTON–PROTON COLLISIONS AND THE FIREBALL MODEL. Lin, Maung Thet. Ann Arbor, Mich.; Univ. of Michigan (1968). 78p.

Thesis.

Data were measured and extended on the center-of-mass differential production cross sections, $d^2\sigma/d\Omega dP$, for pions, kaons and protons to high transverse momenta in 12.5 GeV/c proton–proton collisions. Also the angular distribution of pion production in the fireball frame moving forward with $\beta_F = .54$ with respect to the center-of-mass system and at a momentum $P_F = .7$ (GeV/c) was surveyed. The experiment was conducted at the Argonne ZGS using the external proton beam line. The ranges of measurements covered in this experiment are $P_\perp^2 = 1.0 \rightarrow 4.0$ (GeV/c)$^2$ at $P_i^{cm} = 0.6$ GeV/c for pions, $P_\perp^2 = 1.4 \rightarrow 2.0$ (GeV/c)$^2$ at $P_i^{cm} = 0.6$ GeV/c for $K^+$, and $\theta_{cm} = 63° \rightarrow 80°$ at $P_{cm} = 1.4$ GeV/c and $P_{cm} = 2.1$ GeV/c for protons. Also measured are points at the fireball angles $\theta_F = 0 \rightarrow 110°$ for pion production. The detecting system consisted of a single-arm spectrometer with two bending magnets and a telescope of scintillation counters and Čerenkov counters. The target was a 3-inch-diameter vertical cylinder of liquid hydrogen kept at a fixed low temperature by means of a helium refrigerator. A gold-foil irradiation procedure calibrated two telescopes of monitor counters to read the flux of protons arriving at the target. The cross sections for production of particles were found to be unambiguously Gaussian in transverse momentum: $d^2\sigma/d\Omega dP = B \exp(-AP_\perp^2)$. For $\pi^+$, $K^+$ production, the slopes are $A \approx 2.7$ (GeV/c)$^{-2}$ in the experimental range. Combined with the data of a previous experiment, two slopes $A \approx 3.3$ and 2.7 (GeV/c)$^{-2}$ are observed with a break at $P_\perp^2 \sim 1.4$ (GeV/c)$^2$. For the proton inelastic production, the cross sections were found to have the Gaussian slopes $A \simeq 2.9$ (GeV/c)$^{-2}$ at $P_{cm} = 1.4$ (GeV/c) where pions, protons and kaons are simultaneously producible and $A \simeq 2.3$ (GeV/c)$^{-2}$ at $P_{cm} = 2.1$ (GeV/c) where pions and protons but no kaons are simultaneously producible. The equality of these slopes to the second elastic slope constitute the evidence that the three regions observed in p-p elastic scattering with the Gaussian slopes of 8.6, 2.96 and 1.2 (GeV/c)$^{-2}$ have no simple connections to the $\pi$, K and probably $\bar{p}$ productions. It was also found that the angular distribution of produced pions in the fireball frame is indeed isotropic in the front face but shows anisotropy in the back face. Finally some evidence was found that the productions might be describable by the single relation $(d^2\sigma/d\Omega dP)_F = Be^{-AP_\perp^2}F$ in the fireball system. (Diss. Abstr.)

**15471** $\bar{p}p$ ELASTIC SCATTERING IN THE MOMENTUM RANGE 1.24 TO 1.62 GeV/c. Cooper, W. A.; Hodges, D.; Hyman, L.; Jach, T.; Loken, J.; Manner, W.; Musgrave, B.; Royston, R. (Argonne National Lab., Ill.). Nucl. Phys.; B16: 155-60(1970).

The $\bar{p}p$ elastic cross section was measured at incident antiproton momenta of 1.24, 1.32, 1.54 and 1.62 GeV/c to be 43.2 ± 3.5, 43.3 ± 3.0, 38.5 ± 3.0 and 37.2 ± 3.0 mb respectively. The differential cross section in this momentum range is dominated by a diffraction peak for which the slope is found to decrease with incident momentum, consistent with the established "anti-shrinkage" of the $\bar{p}p$ diffraction peak. The differential cross section shows a well-defined dip at $\cos\theta_{cm} \approx 0.4$ followed by a broad maximum and a sharp backward peak largely confined to the interval $\cos\theta_{cm} < -0.8$. (auth)

**15472** MEASUREMENT OF THE SLOPE PARAMETER FOR DIFFERENTIAL CROSS SECTION OF ELASTIC pp SCATTERING IN THE ENERGY INTERVAL 12 TO 70 GeV. Beznogikh, G. G.; Buyak, A.; Zhidkov, N. K.; (and others) (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 10: 1212-22(1969). (In Russian).

The experiment is carried out on the machine of Serpukhov Institute of High Energy Physics. The accelerated protons were passed repeatedly through thin polyethylene target. Emission angles and energies of the recoil particles were measured by means of semiconductor detectors. The apparatus operated on line with a computer. The relative differential cross section of elastic pp scattering in the energy interval 12 to 70 GeV at small scattering angles ($0.01 < |t| < 0.12$ (GeV/c)$^2$) is measured with accuracy 2 to 3%. The slope is determined of the differential cross section of elastic pp scattering for the mentioned values of the energy and momentum transfer. The slope parameter $b_j$ is shown to increase with energy. The energy dependence is approximated by means of the formula $b_j = b_0 + 2b_1 \ln(s/s_0)$, where $b_0 = 6.8 + 0.3$ (GeV/c)$^{-2}$, $b_1 = 0.47 \pm 0.09$ (GeV/c)$^{-2}$, s is the total c.m.s. energy squared. In framework of the five-Regge-pole model the obtained data result in the following value for the slope of the Pomeranchuk pole trajectory: $\alpha_{P'} = 0.40 \pm 0.09$. (auth)

**15473** NEUTRON–PROTON AND NEUTRON–DEUTERON TOTAL CROSS SECTIONS AT 4.0 AND 5.7 GeV/c. Parker, E. F. (Univ. of Michigan, Ann Arbor); Gustafson, H. R.; Jones, L. W.; Longo, M. J.; Ramana Murthy, P. V.; Ringia, F. E.; Cork, B. Phys. Lett.; 31B: 246-9(16 Feb 1970).

The np and nd total cross sections were measured directly with a neutron beam with momenta of 4.0 ± 0.6 and 5.7 ± 0.6 GeV/c. The data are compared with the previous nucleon–nucleon and nucleon–deuteron results, and the deuteron screening term was also evaluated. The measured total cross sections are 43.1 ± 0.6 and 80.3 ± 1.9 mb at 4.0 GeV/c and 42.5 ± 0.6 and 77.8 ± 1.3 mb at 5.7 GeV/c. (auth)

**15474** NEUTRON–NUCLEUS TOTAL CROSS SECTIONS AT 5.7 GeV/c. Parker, E. F. (Univ. of Michigan, Ann Arbor); Dobrowolski, T.; Gustafson, H. R.; Jones, L. W.; Longo, M. J.; Ringia, F. E.; Cork, B. Phys. Lett.; 31B: 250-2(16 Feb 1970).

The neutron total cross sections for He, Be, C, Al, Fe, Cu, Cd, W, Pb and U were measured to an accuracy of 2% at 5.7 ± 0.6 GeV/c. The total cross section versus atomic weight data was fit to an absorbing uniform grey sphere optical model. The best fit parameters are $R = a_0 A^{\frac{1}{3}}$ where $a_0 = 1.27 \pm 0.01$ fm, and a nucleon mean free path in nuclear matter of 3.0 ± 0.2 fm. The energy dependence of the nucleon–nucleus total cross sections is discussed in terms of the nucleon–nucleon total cross sections and a screening term. (auth)

**15475** ABSORPTION CROSS-SECTIONS OF 25 GeV/c ANTI-DEUTERONS IN Li, C, Al, Cu, AND Pb. Binon, F.; Denisov,

S. P.; Donskov, S. V.; (and others) (Inst. for High Energy Physics, Serpukhov, USSR). Phys. Lett.; 31B: 230-2(16 Feb 1970).

Absorption cross sections were measured for the interaction of antideuterons in lithium, carbon, aluminum, copper, and lead targets at 25 GeV/c, using the standard transmission technique. Similar measurements were also made for pions and antiprotons. The comparison of the various absorption cross sections shows that nuclei are black for $\bar{p}$ and $\bar{d}$ but that the values are much larger for $\bar{d}$ than for $\bar{p}$. (L.B.S.)

### *Strong (Meson-Induced)*

*Refer also to abstracts 15463, 15584, 15587, and 15595.*

**15476** (CEA-R-3928) A STUDY OF THE REACTIONS $\pi^-p \rightarrow \pi^-\pi^0p$ AND $\pi^-p \rightarrow \pi^+\pi^-n$ BELOW 1 GeV. Smadja, Gerard (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Feb 1970. 149p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Univ. of Paris, Orsay, France.

A set of experiments on $\pi^-p \rightarrow \pi^-\pi^0p$, $\pi^-p \rightarrow \pi^+\pi^-n$ reactions, at center of mass energies ranging between 1.4 and 1.5 GeV, is described. The results are expressed in terms of partial waves, in the framework of the isobar model. The domain of validity of this model is studied, and an extension is proposed, within a three body K matrix formalism. This enables one to connect resonances with a high inelasticity and three-body production mechanisms. (auth)

**15477** (INP-681, pp 150-70) EXPERIMENTS WITH THE CERN BOSON SPECTROMETER AND THE QUARK MODEL. Bosnjakovic, B. (European Organization for Nuclear Research, Geneva (Switzerland)).

Experimental results are described which have recently become of interest for the theory of meson classification. The experiments were performed by a collaboration of CERN, the University of Geneva, and Munich University. The idea and experimental setup of the CERN boson spectrometer is described. Also results are presented, and implications concerning especially the quark model are discussed. (J.F.P.)

**15478** 4-PRONG PLUS NEUTRAL VEE PRODUCTION IN 4.25-BeV/c $K^-p$ COLLISIONS. Yost, George Palmer. College Park, Md.; Univ. of Maryland (1969). 246p.

Thesis.

Interactions of negative kaons with protons leading to final states containing four charged prongs plus a neutral Vee decay were investigated using the Brookhaven National Laboratory 80" hydrogen bubble chamber exposed to a 4.25-GeV/c $K^-$ beam from the AGS. Partial cross sections for the observed final states are presented. The 3-body reaction $K^-p \rightarrow K^{*-}\Delta^{++}\pi^-$ was studied in detail and an analysis in terms of a multiperipheral diagram was carried out. Evidence is given for the production of an $\omega\pi\pi$ resonance in the reaction $K^-p \rightarrow \Lambda 5\pi$. The mass and width of the resonance are 1670 MeV and 50 MeV respectively. No conclusive inference can be made as to its isospin, spin or parity. (Diss. Abstr.)

**15479** $\bar{K}^0$ FINAL STATES FROM THE INTERACTION OF $K^-$ MESONS ON DEUTERIUM AT 4.5 GeV/c. Eisner, Robert Lawrence. Lafayette, Ind.; Purdue Univ. (1969). 148p.

Thesis.

A study of the interactions of 4.5 GeV/c $K^-$ mesons on deuterium is reported. The 400,000-picture exposure was taken in the MURA thirty-inch bubble chamber at the Argonne Zero Gradient Synchrotron (ZGS). The $\bar{K}^0$ final states from the two prong plus vee topology are discussed. The reactions investigated include, $K^-d \rightarrow \bar{K}^0\pi^-pn$ (1), $K^-d \rightarrow \bar{K}^0\pi^-d$ (2), $K^-d \rightarrow \bar{K}^0\pi^-\pi^0d$ (3), and $K^-d \rightarrow \bar{K}^0\pi^-$ M.M. (4). Production of the $K^*(890$ resonance was analyzed from both proton and neutron interactions and compared with the theoretical prediction of Donohue. There is evidence for constructive pion-vector interference at low momentum transfers in the $K^-n$ and destructive interference in the $K^-p$ reactions. $N^{*-}(1238)$ production in (1) is examined in the light of papers by Thews and Maor and Kraemmer. Strong $K^{*-}(890)$ production dominates (2). There is evidence for vector exchange ($\omega$) contributing to the production of the $K^*(890)$ at low momentum transfers. The $d^*$ enhancement is quite strong in (3). $K^*$-$d^*$ production is discussed. (Diss. Abstr.)

**15480** CONFIRMATION OF A NEW $A\pi$ RESONANCE IN THE REACTION $K^-n \rightarrow A\pi^+\pi^-\pi^-$. Ammann, A. C. (Purdue Univ., Lafayette, Ind.); Garfinkel, A. F.; Carmony, D. D.; Gutay, L. J.; Miller, D. H.; Yen, W. L. Phys. Rev. Lett.; 24: 327-31(16 Feb. 1970).

Evidence is presented to confirm the existence of a new $A\pi$ resonance in the $A\pi^+\pi^-\pi^-$ final state from $K^-d$ interactions at 4.5 GeV/c. A mass of 1642 ± 12 MeV and a width of 55 ± 24 MeV are obtained. Upper limits on $\Sigma\pi$ and $\Lambda(1405)\pi$ branching ratios are found to be consistent with an octet assignment. (auth)

**15481** FORWARD STRUCTURE OF THE SINGLE-PION-PRODUCTION AMPLITUDE. Scharenguivel, J. H. (Purdue Univ., Lafayette, Ind.); Gutay, L. J.; Miller, D. H.; (and others). Phys. Rev. Lett.; 24: 332-6(16 Feb 1970).

The momentum-transfer dependence of the cross section and density matrix elements for single-pion production in pion-nucleon collisions was measured. The results show nonevasive contributions for small t. A forward peak is seen in the extrapolated transverse cross section, in qualitative agreement with some versions of vector-meson dominance. (auth)

**15482** SEARCH FOR $\Sigma(1616)$ IN $K^-d$ INTERACTIONS AT 3 GeV/c. Barloutaud, R. (CEN, Saclay, France); Merrill, D. W.; Scheuer, J. C.; (and others). Nucl. Phys.; B16: 201-8(1970).

No evidence has been found for the production of $\Sigma(1616)$ in the reaction $K^-n \rightarrow \Sigma(1616)\pi^+\pi^-$ ($\Sigma(1616) \rightarrow \Lambda\pi^+$) at 3 GeV/c. The reaction $K^-n \rightarrow \Sigma^-(1660)\pi^+\pi^-$ ($\Sigma^-(1660) \rightarrow \Sigma^0\pi^-$) occurring at this incident momentum appears to be responsible for the small enhancement seen in the $A\pi^-$ mass distribution around 1620 MeV. (auth)

**15483** REACTIONS $K^-n \rightarrow K^{*-}n$ AND $K^-n \rightarrow K^0N^{*-}$ AT 3 GeV/c. Bakker, G. (Zeeman-Laboratorium, Amsterdam); Hoogland, W.; Tenner, A. G.; (and others). Nucl. Phys.; B16: 53-60(1970).

The production and decay characteristics of the $K^*(895)$ and $N^*(1236)$ are studied in the reactions: $K^-n \rightarrow K^{*-}n$ and $K^-n \rightarrow K^0N^{*-}$. The results are compared with the predictions of the absorption model. (auth)

**15484** A STUDY OF THE REACTION $\pi^+p \rightarrow \Sigma^+K^+$ AT 1.7 GeV/c. Pan, Yu-li; Forman, L. (Univ. of Pennsylvania, Philadelphia). Nucl. Phys.; B16: 61-8(1970).

Data on the reaction $\pi^+p \rightarrow \Sigma^+K^+$ at 1.7 GeV/c are presented. The cross section for this channel is 0.47 ± 0.04 mb. The results are compared with various theoretical models. In addition, a possible violation of charge independence in the backward direction is found. (auth)

**15485** QUASI-TWO-BODY PRODUCTION IN $K^-n \rightarrow \Sigma^Y$ + MESONS AT 4.94 GeV/c. DiBianca, F. A.; Einschlag, M. B.; Endorf, R. J.; Engler, A.; Fisk, H. E.; Kraemer, R. W.; Yekutieli, G. (Carnegie-Mellon Univ., Pittsburgh). Nucl. Phys.; B16: 69-76(1970).

Data on the following quasi-two-body reactions produced in $K^-n$ interactions at 4.94 GeV/c are presented: $\Sigma^-\pi^0$, $\Sigma^-\eta^0$, $\Sigma^-\rho^0$, $\Sigma^-\omega^0$, $\Sigma^-\eta'^0$, $\Sigma^-\phi^0$, $\Sigma^-f^0$, $\Sigma^-f'^0$, $\Lambda(1405)\pi^-$ and $\Lambda(1520)\pi^-$. Cross sections, four-momentum transfer distributions, and density matrix elements are discussed. Assessment of possible exchange mechanisms and comparisons with the predictions of the quark model are made. (auth)

**15486** DOUBLE-REGGE-POLE MODEL ANALYSIS OF $\pi^-p \rightarrow \pi^-\pi^-\Delta^{++}$ AT 6 GeV/c. Mott, J. E.; Martin, H. J.; Galloway, K. F. (Indiana Univ., Bloomington). Nucl. Phys.; B16: 102-8(1970).

Experimental distributions for all momentum transfers, two-body masses and decay angles in the $\pi^-\pi^-\Delta^{2+}$ final state were obtained and analyzed with two models: diffraction production combined with one-pion exchange and double-Regge-trajectory exchange. The double-Regge-Pole model yields a good description of the data even when all allowed values of final state two body masses are used, an approach justified by duality. (auth)

**15487** PRODUCTION OF $K^*(892)$ IN $K^+N$ INTERACTIONS AT 3 GeV/c. Bassompierre, G. (CERN, Geneva); Goldschmidt-Clermont, Y.; Grant, A.; (and others). Nucl. Phys.; B16: 125-54(1970).

A study was made of the reactions (1) $K^+d \rightarrow K^+\pi^-pp$, (2) $K^+d \rightarrow K^0\pi^0pp$, and (3) $K^+d \rightarrow K^0\pi^+pn$, obtained from an exposure of the Saclay 81-cm bubble chamber filled with deuterium and exposed at CERN to a separated 3 GeV/c $K^+$ beam. In reactions (1) and (2) there is abundant production of $K^{*0}(892)$ and some production of $K^*(1420)$. From the density matrix elements, it is found that $K^{*0}(892)$ is produced mainly by pion exchange. The $K^*(892)$ four-momentum-transfer distribution in reaction (1) agrees with the predictions of the OPE model, as modified by Dürr and Pilkuhn. A marked asymmetry of the decay distribution of the $K^+\pi^-$ system is observed and discussed in the framework of a unitarized Veneziano model. In reaction (3), on the other hand, the production of $K^{*+}(892)$ and $N^{*2+}(1236)$ is found to proceed mainly by vector exchange. (auth)

**15488** DECAY-PROPERTIES OF THE "$A_2(1300)$"-MESON. Boeckmann, K. (Univ., Bonn); Rost, M.; Wagini, B.; (and others). Nucl. Phys.; B16: 221-38(1970).

The decay properties of the $A_2$-meson are studied in the reac-

tions $\pi^+p \to pA_2^+$ and $\pi^+p \to \Delta^{2+}A_2^0$ at 5 GeV/c. Branching ratios into $\rho\pi$, $\eta\pi$, $K\bar{K}$ and $X\pi$ are given. A $J^P$ Dalitz-plot analysis of the total $A_2^0$ peak confirms the $2^+$ assignment. A double peak analysis excludes $1^-$ as a pure state in either half and favors $2^+$ in both. (auth)

**15489** INVESTIGATION OF CHANNELS OF THE REACTION $\pi^-p \to n\pi^+\pi^-m\pi^0$ AT pc = 4 GeV. Grishin, V. G.; Iresh, M.; Kopylova, D. K.; (and others) (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 10: 1204-11(1969). (In Russian).

Reaction $\pi^-p \to n\pi^+\pi^-m\pi^0$ at pc = 4 GeV was investigated by means of the 24.1 propane chamber at LHE of JINR. 150,000 stereo pictures were scanned and 2374 events were detected. The following cross sections are determined: $\sigma(\pi^-p \to n\pi^+\pi^-\pi^0) = 2.3 \pm 0.5$ mbarn, $\sigma(\pi^-p \to n\pi^+\pi^-2\pi^0) = 2.0 \pm 0.4$ mbarn, $\sigma(\pi^-p \to n\pi^+\pi^-3\pi^0) = 0.45 \pm 0.2$ mbarn, and $\sigma(\pi^-p \to n\omega\pi^0) = 0.6 \pm 0.15$ mbarn. Momentum and angular parameters of $\pi^+$ mesons in the c.m. system are obtained. (auth)

**15490** QUASI-TWO-BODY PROCESSES IN $\pi^+$-d INELASTIC REACTIONS AT 5.1 GeV/c. Armenise, N. (Univ., Bari, Italy. Istituto Nazionale di Fisica Nucleare, Bari, Italy); Ghidini, B.; Picciarelli, V.; (and others). Nuovo Cim.; 65A: 637-53(21 Feb 1970).

Experimental results are presented on the quasi-two-body reactions observed in the $\pi^+$-d interactions at 5.1 GeV/c. Total and differential cross sections and spin-density matrix elements are compared with the predictions of the exchange models. (auth)

**15491** MEASUREMENT OF THE $K^-p \to K^0n$ CROSS SECTION FROM 1 TO 32 GeV/c. Bricman, C. (CERN, Geneva); Ferro-Luzzi, M.; Perreau, J.-M.; Bizard, G.; Declais, Y.; Duchon, J.; Seguinot, J.; Valladas, G. Phys. Lett.; 31B: 148-51(2 Feb 1970).

The $K^-p \to \bar{K}^0n$ partial cross section was measured in the region of $K^-$ laboratory momenta from 1 to 3 GeV/c, in steps of ~25 MeV/c and with a statistical accuracy of ~2%. (auth)

**15492** FORMATION OF S = −1 HYPERON RESONANCES WITH MASSES BETWEEN 1.8 AND 2.6 GeV. Bricman, C. (CERN, Geneva); Ferro-Luzzi, M.; Perreau, J.-M.; Bizard, G.; Declais, Y.; Duchon, J.; Seguinot, J. Phys. Lett.; 31B: 152-6(2 Feb 1970).

Accurate measurements of the charge-exchange reaction $K^-p \to \bar{K}^0n$ between 1 and 3 GeV/c were used to analyse the direct-channel formation of hyperon resonances. An overall fit to the charge-exchange data and the $K^-p$ total cross sections was obtained, from which a set of resonant parameters (mass, width, elasticity and spin) is presented for a total of 10 resonances lying between ~1.8 and ~2.6 GeV. (auth)

**15493** GENERAL CHARACTERISTICS OF $\pi^-$-NUCLEON INTERACTIONS AT 60 GeV/c OBTAINED IN NUCLEAR EMULSION. Anzon, E. V. (Inst. of Nuclear Physics, Alma-Ata, USSR); Chasnikov, I. Ya.; Shakhova, Ts. I.; (and others). Phys. Lett.; 31B: 237-40(16 Feb 1970).

Interactions of 60 GeV/c $\pi^-$-mesons with nucleons of the nuclear emulsion were studied. Average prong number in $\pi^-$-proton collisions is 6.64 ± 0.16. The majority of secondary particles are emitted into the forward hemisphere in the $\pi^-$-proton CM system especially in low-multiplicity events. (auth)

**15494** CROSS SECTIONS OF $\pi^-p$ INTERACTIONS AT 20 GeV. Balea, E.; Balea, O.; Coca, C.; Sabau, M.; Sahini, M. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 693-7(1969).

The first part of a general study on the multiple-production in $\pi^-p$ interactions at 20 GeV, using the 81-cm Saclay hydrogen bubble chamber, is reported. Cross sections for different multiplicities and total cross sections are presented. (L.B.S.)

**15495** COHERENT PRODUCTION OF PARTICLES BY 60 GeV/c PIONS ON EMULSION NUCLEI. Anzon, E. V. (Inst. of Nuclear Physics, Alma-Ata, USSR); Chasnikov, I. Ya.; Shakhova, Ts. I.; (and others). Phys. Lett.; 31B: 241-5(16 Feb 1970).

In the study of interactions of 60 GeV/c $\pi^-$-mesons in nuclear emulsion some peculiarities of the prong-number distribution and the angular distribution of secondaries were observed. They are interpreted in terms of the coherent production of three and five pions on emulsion nuclei. The cross section for these reactions increases with the increasing energy. (auth)

**15496** SCATTERING OF NEGATIVE PIONS ON CARBON. Binon, F. (CERN, Geneva. FNRS, Brussels); Duteil, P.; Garron, J. P.; Gorres, J.; Hugon, L.; Peigneux, J. P.; Schmit, C.; Spighel, M.; Stroot, J. P. Nucl. Phys.; B17: 168-88(1970).

Data are presented on elastic and inelastic differential cross sections as well as on total cross sections for negative pions on carbon in the energy range 120 MeV to 280 MeV. (auth)

**15497** EVIDENCE FOR PION EXCHANGE IN $K^-p \to K^*\pi N$ AT 3 GeV/c. Colton, Eugene (Univ. of California, Los Angeles); Prum, Samuel; Schlein, Peter E.; Verglas, Alain J. Nucl. Phys.; B17: 117-26(1970).

Peripheral K*(891) production is observed in states leading to $K^-p \to K^0\pi^-\pi^0p$, $K^-p \to K^0\pi^-\pi^+n$, and $K^-p \to K^-\pi^+\pi^-p$ at 3 GeV/c. The data for $K^-p \to K^*(891)\,\pi N$ are consistent with the absolute predictions of one-pion exchange with off-mass-shell $K\pi$ and $\pi N$ scattering at the two vertices. However, I = 0 exchange, when allowed, appears to dominate for $\pi N$ masses greater than 1.4 GeV. (auth)

**15498** PION–NUCLEON SCATTERING. Cence, Robert J. Investigations in Physics, Volume 11. Princeton, N. J.; Princeton University Press (1969). 145p. $6.50.

A summary of research in the last ten years in the field of pion–nucleon scattering at high energies is presented. Elementary scattering theory, total cross sections, the forward amplitude, elastic scattering and polarization, phase shift analysis, inelastic scattering, photoproduction, and various models are discussed. (J.F.P.)

# Particle Interactions and Properties (Theoretical)

## General

*Refer also to abstracts 15638, 15677, and 15678.*

**15499** (INP–681) PROCEEDINGS OF THE IX CRACOW SCHOOL OF THEORETICAL PHYSICS. Volume I. (Institute of Nuclear Physics, Krakow (Poland)). Jun 1969. 241p. Dep. CFSTI (U. S. Sales Only).

Eleven lectures are included. Separate abstracts were prepared for each lecture. (J.F.P.)

*For abstracts of individual lectures see: 15477, 15541, 15553, 15579, 15597, 15626, 15629, 15635, 15636, 15677, and 15678.*

**15500** (LYCEN–7001) A GRAPHICAL TREATMENT OF WICK'S THEOREM. Meyer, Jacques; Sau, Jacques; Massot, Jean-Noeel (Lyon Univ. (France). Institut de Physique Nucleaire). 5 Jan 1970. 22p. Dep. CFSTI (U. S. Sales Only).

A graphical method is used to rearrange a sequence of annihilation and creation operators in order to obtain systematically all the terms given by the Wick's theorem. An application of this method is given for the calculation of a commutation relation. (auth)

**15501** THEORY OF ELEMENTARY PARTICLES AND THE NONINVARIANT VACUUM. Grib, A. A. (Zhdanov State Univ., Leningrad). Dokl. Akad. Nauk SSSR; 187: 1022-4(11 Aug 1969). (In Russian).

S. Coleman's recent theorem states that the invariance is the invariance of the universe. In this connection the question arises that the vacuum is noninvariant. This problem was examined by presenting a mathematical construction of the field theory, in which the vacuum is considered noninvariant with respect to a number of internal conversions. The problem of distinct determination of the vacuum in the quantum field theory is related to the concept of canonic adjustable relations for systems with an infinite number of freedoms. Some of the physical examples of the noninvariant concept, such as nonconservation of the isotopic invariance, of SU(3), and of the strangeness, were examined. (TTT)

**15502** N/D EQUATIONS WITH REGGE-POLE INELASTICITY. Tataru-Mihai, P. (Univ. Babes-Bolyai, Cluj). Lett. Nuovo Cim.; 3: 146-8(29 Jan 1970).

Previous results on Regge-pole inelasticity functions and partial-wave driving forces at large energies for pion–pion and pion–nucleon scattering are used in the N/D formalism to obtain a simple model for partial-wave calculations. Restriction is made to the interactions of neutral spinless particles. (J.F.P.)

**15503** ROLE OF THE MASS IN THE THEORY OF FERMIONS. Leite Lopes, J.; Novello, Mario (Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro). Rev. Mex. Fis.; 18: 425-35(1969).

The possibility of regarding the mass as an operator in Dirac's equation for free fermions is investigated. The mass transformation induced by general coordinate transformations which leave invariant Dirac's equation is obtained and includes mass-reversal. Invariance under the Poincaré group imposes strong restrictions on the mass-transformation but seems to allow mass-reversal. (auth)

**15504** PARTICLE PHYSICS. Proceedings of the 8th International Conference on Particle Physics, Schladming, Austria, 24th February–8th March 1969. Urban, Paul (ed.). Acta

Physica Austriaca, Supplement VI. Vienna; Springer-Verlag (1969). 558p. $24.50. (CONF-690219).

Sixteen papers are included. Summaries are also included of the papers presented during the first and second weeks. A separate abstract was prepared for each of the 16 papers. (L.B.S.)

*For abstracts of individual papers see: 15519, 15536, 15547, 15548, 15567, 15568, 15590, 15607, 15613, 15628, 15649–15652, 15685, and 15686.*

15505 ONE-PARTICLE EXCHANGE MODEL FOR LOW-ENERGY AMPLITUDES. Banyai, L. (Inst. of Physics, Bucharest). Stud. Cercet. Fiz., 21: 731-75(1969). (In Rumanian).

The N/D method, bootstrap, the one-dimensional Cini-Fubini representation for the $\pi\pi$ scattering and the OPE model, the physical interpretation of the model in the spirit of the Feynman graphs, partial waves and the equations of the spectral densities. Also covered are the $\mathcal{K}$-matrix formalism and the program of successive approximations, selfconsistency ("boostrap") conditions, narrow resonances, scattering of unequal mass particles and the many two-particle channels problems, and many-channel resonances. The $\pi-\pi$ scattering amplitude, selfconsistent computation of the $\rho$ resonance, the I = 1, J = $1\pi\pi$ amplitude with the experimental $\rho$ resonance and selfconsistent computation of the ABC antibound state. (auth)

## Electromagnetic

*Refer also to abstracts 15426, 15427, 15429, 15446, 15611, 15662, and 15812.*

15506 (AD-696698) SEARCH FOR THE PROCESS ELECTRON AND ELECTRON YIELDS TWO NEGATIVE MUONS. Cheng, David C. (Princeton Univ., N. J. Palmer Physical Lab.). 1 May 1969. Contracts Nonr-1858(39); AT(30-1)-2098; AT(04-3)-515. 102p. CFSTI.

Thesis.

In order to make a sensitive test of whether a multiplicative or an additive lepton number conservation law is at work in leptonic reactions, the process ($e^+e \rightarrow \mu^{2-}$) was searched for using colliding beams. The result of the experiment sets an upper limit on the cross-section of $0.8 \times 10^{32-}$ cm$^2$. A phenomenological Hamiltonian describing a point interaction of strength G can be introduced for the process. (auth)

15507 (SU-1206-217) HIGH-ENERGY ELECTROPRODUCTION AND THE lim $q^2\sigma_L = 0$ AS $q^2 \rightarrow -\infty$. Chanda, R.; Sen, S. (Maryland Univ., College Park. Dept. of Physics and Astronomy); Majumdar, D. P. (Syracuse Univ., N. Y. Dept. of Physics). Nov 1969. 9p. (NYO-3399-217). Dep. CFSTI.

It is shown that the result lim $q^2\sigma_L = 0$ as $q^2 \rightarrow -\infty$ can be obtained without making any explicit assumptions regarding the nature of the constituents of the hadronic electromagnetic current. (auth)

15508 HADRON STATES OF EVEN CHARGE CONJUGATION FROM ELECTRON–POSITRON ANNIHILATION. Creutz, Michael J.; Einhorn, Martin B. (Stanford Univ., Calif.). Phys. Rev. Lett.; 24: 341-3(16 Feb 1970).

It is shown how electron-positron storage rings may be used to obtain information on hadronic states with even charge conjugation. This is illustrated by studying the reaction $e^-e^+ \rightarrow \pi^-\pi^+\gamma$, the analysis of which should reveal information on even-C di-pion resonances, such as the existence of the $\epsilon$ meson. (auth)

15509 TEST OF VECTOR-MESON DOMINANCE MODEL IN THE COLLIDING-BEAM REACTION $e^+e^- \rightarrow P + \gamma$. Etim, E.; Picchi, P. (CNEN, Frascati, Italy). Lett. Nuovo Cim.; 2: 887-94(21 Dec 1969).

The prediction of gage field algebra and quark field algebra for the processes $e^+e^- \rightarrow \pi^0 + \gamma$ and $\pi^0 \rightarrow \gamma + \gamma$ are compared, and it is found that the gage field result is in conflict with experiment while the quark field is definitely favored. It is shown, by using the field-current identity sum rule for F$\pi$, why the vector-meson dominance prediction for the width $\Gamma(\pi^0 \rightarrow 2\gamma)$ was claimed to be in better agreement with experiment than any other model. Proposed tests of particle models using storage rings are briefly discussed. (L.B.S.)

15510 PION PHOTOPRODUCTION TREATING NUCLEI AS ELEMENTARY PARTICLES. Pascual, P.; Sanchez-Gomez, J. L. (Univ. of Valencia, Spain). Nucl. Phys.; B16: 191-200 (1970).

A new formulation of pion photoproduction, when all intervening nuclei are treated as elementary particles, is presented. Using the covariant spin formalism, invariant form factors are introduced. The theory is applied to several cases. (auth)

15511 NUCLEON FORM FACTORS AND ASYMPTOTIC SYMMETRIES. Pietschmann, H.; Stremnitzer, H. (Univ., Vienna). Lett. Nuovo Cim.; 2: 841-5(21 Dec 1969).

The conditions that are necessary to fit both the proton and neutron form factors in terms of resonances are discussed. The asymptotic mass of $\rho'$ is fixed by modification of the condition for asymptotic behavior of the electric neutron form factor. The calculated values of $G_M/\mu p$ are compared with measured values of different groups. (L.B.S.)

15512 DEVELOPMENT OF THE ELECTRON–PHOTON SHOWER IN THE LAYERED MEDIUM. Gerasimova, N. M. (Inst. of Nuclear Physics, Moscow). Yadern. Fiz.; 10: 1223-7 (1969). (In Russian).

The method of consistent calculations of the transition effects in the medium, consisting of the alternated thin and thick layers of different materials is proposed. As an example the number of the electrons behind the double-layer absorber is calculated in the B-approximation. The generalization of the method on the any number of the layers is proposed. (auth)

15513 OFF-MASS-SHELL FORM FACTORS OF THE NUCLEON. Komatsuzawa, A. (Kansai Univ., Suita, Japan); Nakazawa, K.; Sugano, R. Nuovo Cim.; 65A: 597-606(21 Feb 1970).

Off-mass-shell form factors of the nucleon are investigated. The six unknown form factors can be combined into three independent ones using the projection operators of the virtual nucleon state with mass W ≠ M. With the aid of the Ward-Takahashi identity and the Bjorken limit, some relations between the form factors and the asymptotic behavior are derived. It is concluded from the asymptotic behavior of the off-mass-shell form factors that the ordinary vector-meson-dominant model contradicts these asymptotic conditions, unless the vector-meson–nucleon coupling also has a structure. Hence, the dipole model is more reasonable than the simple-pole model. Finally, the effect of the off-mass-shell form factors to the electromagnetic self-energy of the nucleon is discussed. (auth)

15514 CONCERNING A THEORETICAL PARADOX IN CLASSICAL ELECTRODYNAMICS. Grandy, W. T. Jr. (Univ. of Wyoming, Laramie). Nuovo Cim.; 65A: 738-42(21 Feb 1970).

A recently noted "paradox" within the classical theory of electrodynamics is discussed, and resolved. Since it is apparent that some confusion exists regarding advances made in the classical theory during the past ten years, the concept of energy conservation for radiating charged particles is reviewed. (auth)

15515 UNITARITY AND VENEZIANO-LIKE PION FORM FACTOR. Drago, F.; Grillo, A. F. (CNEN, Rome). Nuovo Cim.; 65A: 695-706(21 Feb 1970).

A unitarization method is studied in connection with the recently proposed Veneziano-like models for the pion electromagnetic form factor. Using as input the model proposed by Suura, good agreement is obtained with the experimental data in the timelike region. (auth)

15516 VENEZIANO MODELS FOR VIRTUAL COMPTON SCATTERING. Brower, R. C.; Rabl, A.; Weis, J. H. (Univ. of California, Berkeley). Nuovo Cim.; 65A: 654-74(21 Feb 1970).

Recently proposed Veneziano-type models for Compton scattering of neutral and charged currents are studied. Current commutators, sum rules, large-$q^2$ behavior and factorizability are investigated. A new model is proposed which has good behavior in all these respects. Electroproduction phenomenology and electromagnetic-mass differences are discussed. (auth)

15517 LOW-ENERGY THEOREMS FOR COMPTON SCATTERING ON A SPIN-$^3/_2$ TARGET. Leal Ferreira, G. F.; Ragusa, S. (Instituto de Fisica Teorica, Sao Paulo, Brazil). Nuovo Cim.; 65A: 607-16(21 Feb 1970).

Low-energy theorems are derived for the scattering of light on a target of spin $^3/_2$. The general method of Pais for an arbitrary spin target is used but a simpler argument is given to predict which amplitudes obey the low-energy theorems. (auth)

15518 POSSIBILITY OF THE GENERATION OF ELECTRON–POSITRON PAIRS IN VACUUM DURING FOCUSING OF LASER RADIATION. Bunkin, F. V.; Tugov, I. I. (Lebedev Inst. of Physics, Moscow). Dokl. Akad. Nauk SSSR, 187: 541-4(July 11, 1969). (In Russian).

The possibility of "pulling" out real particle pairs of electrons and positrons by means of an external field from a vacuum has been predicted by quantum electrodynamics, but has not been predicted by quantum electrodynamics, but has not been realized experimentally because of the necessity of having an electric field with a tension approaching the critical value $E_c = 1.32 \times 10^{16}$ volts per cm. The problem of generating electron-positron pairs in the electromagnetic field occurring on focusing coherent

laser radiation in a vacuum by means of an ideal lens is considered by introducing a Lagrangian function of the electromagnetic field that depends on values of the field invariants at a given moment of time. This equation contains eigen values which are an analytical reflection of the fact that particle pairs are generated in a system which is initially in a state of vacuum. An expression is given for the probability that the system remain in a state of vacuum, and an expression is derived for the number of electron-positron pairs generated in an electromagnetic field per unit volume and time. It is estimated that a total laser power of $10^{19}$ watts is required to generate one pair in vacuum by passing a pulse of laser radiation through an ideal lens for a period of $10^{-11}$ seconds and at a wavelength of 6900 Å. This laser power is not attainable at present. A transition from nanosecond to picosecond durations would lower the power requirement to $10^{14}$ watts which is attainable. (TTT)

**15519** MISCELLANEOUS TOPICS RELATED TO THE ANNIHILATION OF AN ELECTRON–POSITRON PAIR INTO MESONS. Gourdin, M. (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). Acta Phys. Austr.; Suppl. 6, 350-434(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The general structure of the $e^+e^-$ annihilation cross section is discussed in part I in a model-independent manner, using only the assumption that the annihilation electron-positron proceeds via the one-photon exchange approximation. In part II, the vector-meson dominance model is treated. The models for the mixing of $\omega$ and $\phi$ are examined in part III. (L.B.S.)

**15520** ELECTROMAGNETIC-TRANSITION FORM FACTORS FREE OF KINEMATIC SINGULARITIES. Theis, W. R.; Hertel, P. H. (Freie Univ., Berlin). Nuovo Cim.; 66A: 152-66(1 Mar 1970).

Matrix elements of the electromagnetic currents between one-particle states of spin s and s′ are decomposed into invariant functions free of kinematic singularities which are the usual multipole amplitudes in the nonrelativistic limit. Parity conservation is taken into account. Kinematic constraints occur only at the two physical threshold values and are given explicitly. (auth)

**15521** ELECTROMAGNETIC MASS SHIFTS IN NON-LAGRANGIAN FIELD THEORY. Steinmann, O. (International Centre for Theoretical Physics, Trieste, Italy). Commun. Math. Phys.; 15: 133-55(12 Dec 1969).

The electromagnetic interactions of hadrons are considered in a model in which both the hadrons and the photons are spinless. The perturbation theory of this model is developed in a way which takes the strong interactions rigorously into account. An expression for the second-order electromagnetic mass shifts of the hadrons is derived. The customary formula expressing these mass shifts as integrals over the Compton scattering amplitude is shown to be inaccurate. The correct expression differs from the old one by a changed integration contour. In favorable cases the two expressions coincide if the integrations over the four components of the photon momentum are carried out in a certain order. This order of integration must in general not be changed. (auth)

**15522** COMPARISON OF THE NULL-SPINOR AND CURRENT-CONSERVATION GAUGE CONDITIONS. Tchrakian, D. H. (Westfield Coll., London). Nuovo Cim.; 66A: 1-10(1 Mar 1970).

The null-spinor and current-conservation gauge conditions with respect to photonic reactions are compared. It is found that the latter, which is a sufficiently strong condition, turns out to be the stronger of the two. (auth)

**15523** BREMSSTRAHLUNG IN e–p SCATTERING AND NUCLEON VIRTUALITY. Bunaciu, D.; Costescu, A.; Vescan, T. (Univ. of Bucharest). Rev. Roum. Phys.; 14: 679-80(1969).

An evaluation of the contribution of the virtual proton Compton amplitude to the integrated cross section for wide-angle bremsstrahlung in electron-proton scattering is presented. The integrated cross section formulas were explicitly calculated for the experiments in which either the final electron is detected only, or the direction of the final electron and the energy of the final proton are measured. (L.B.S.)

**15524** π-CONSPIRACY AND FACTORIZATION IN VECTOR MESONS AND Δ(1236) ISOBAR PHOTOPRODUCTION. Ader, J. P.; Capdeville, M. (Faculte des Sciences, Bordeaux). Nucl. Phys.; B17: 127-40(1970).

The most recent experimental results near the forward direction for $\omega$, $\rho$, $\phi$ and $\Delta$ photoproduction are compared with a simple model involving only few Regge-trajectory exchanges. Particular attention was paid to the pion trajectory contribution and the possibilities of conspiracy and evasion were studied. It is found that $\omega$ and $\Delta$ photoproduction indicate a pion conspiracy. A special emphasis was made on the zero suggested by factorization from previous conspiracy fits. It is also shown that this zero is not able to explain $\omega$ and $\Delta$ photoproduction. That implies a violation of factorization and then a new difficulty of the pure Regge-phenomenology approach. (auth)

**15525** CONSIDERATIONS ON THE LORENTZ–DIRAC EQUATION. Cohn, Jack (Univ. of Oklahoma, Norman). J. Math. Phys. (N. Y.); 11: 294-5(Jan 1970).

Charged particles whose motions are described by the Lorentz–Dirac equation are considered. It is proved that, for an arbitrary collection of such classical charges moving solely under mutual electromagnetic interaction, the position of each charge and the force acting on each are infinitely differentiable functions of the proper time throughout any time interval for which the particle separations are all nonzero. A corollary of this result is then shown to be that discontinuous-, step-, or δ-function-type external boundary forces which might act on nonzero-size charged particles are not permissible. (auth)

**15526** WAVEPACKET VOLKOV SOLUTIONS. Meyer, James W. (Purdue Univ., Lafayette, Ind.). J. Math. Phys. (N. Y.); 11: 312-17(Jan 1970).

The problem of a scalar particle interacting with a planewave external field is solved in terms of the complete set of normalized in-states which are present in the asymptotic past. By expressing the field operator in terms of the annihilation and creation operators for the in-states, it is shown that the normal LSZ asymptotic condition holds allowing an unambiguous interpretation of the wavefunctions, i.e., in the sharp-momentum limit of the wavepacket Volkov solutions, the momentum parameter appearing in the solution is the momentum of the particle before the particle entered the beam. A brief discussion on how to include other interactions is also presented. (auth)

**15527** A NOMOGRAM FOR CALCULATING THE ENERGY RELATIONS IN COMPTON SCATTERING. Andrews, Howard L. (Univ. of Rochester, N. Y.). Health Phys.; 18: 158-9(Feb 1970).

The relation of the energy of the incident photon E and that of the scattered photon E′ in a Compton process is given by the equation: $E' = E/[1 + (E/mc2)(1 - \cos\theta)]$. The nomogram presented was developed to permit the rapid solution of this equation without the use of tables, to an accuracy sufficient for the identification of features in the usual gamma ray spectrum. (UK)

## Weak

*Refer also to abstracts 15594, 15632, and 15649.*

**15528** (CERN–69-28, pp 161-7) ON A POSSIBILITY FOR NEUTRINO OBSERVATION FROM COLLAPSING STARS AND NEUTRINO OSCILLATIONS. Domogatskii, G. V.; Zatsepin, G. T. (Akademiya Nauk SSSR, Moscow. Institut Fiziki).

Theoretical investigations of gravitational collapse in the evolution of massive stars resulting in enormous fluxes of high-energy neutrinos are considered. It is expected that the oscillation hypothesis can be verified by the energy analysisof these pulses, and also an upper limit be placed on the neutrino mass. It is assumed in the calculations that the collapsing star is in the center of the galaxy and that the detector contains $10^3$ tons of organic scintillator $(CH_2)_n$. It is found that one event with energy above 10 MeV per year will occur. (J.F.P.)

**15529** PARTIALLY CONSERVED CURRENTS AND THE TADPOLE MODEL IN NONLEPTONIC DECAYS. Graham, R. H.; O'Donnell, P. J. (Univ. of Toronto). Lett. Nuovo Cim.; 3: 74-6(15 Feb 1970).

Under the assumption of tadpole dominance plus PCAC and PCVC, a "no-go" theorem is derived for nonleptonic decays of hyperons and kaons. It is shown that these no-go theorems are consistent with empirical calculations based on use of the Veneziano model for four-point functions. (L.B.S.)

**15530** SIMPLE MODEL FOR THE THREE-BODY DECAYS OF $^4_\Lambda$H. Londergan, J. T. (Oxford Univ.). Nucl. Phys.; B16: 109-18(1970).

The decay spectra for $^4_\Lambda H \to \pi^- + p + {}^3H$ and $^4_\Lambda H \to \pi^- + n + {}^3He$, using a two-channel reaction matrix model for the $p^3H$ and $n^3He$ final-state interactions. The qualitative features of the experimental $^3H$ and $^3He$ momentum distributions, which are quite different in character, are adequately reproduced with this model. (auth)

**15531** DECAY OF MUON IN NONLOCAL THEORY OF WEAK INTERACTIONS. Efimov, G. V.; Sel'tser, Sh. Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 10: 1243-52 (1969). (In Russian).

The prescription giving the possibility to construct a macrocausal unitary and finite S-matrix in the perturbation theory for four fermion interaction is suggested. Second-order perturbational correction to the muon decay probability and to the spectrum of emitted electrons is calculated in nonlocal theory of weak interactions. After the weak coupling constant is renormalized the correction to the electron spectrum is small up to the elementary lengths $l \gtrsim 10^{-19}$ cm. (auth)

**15532** ON THE HARD-PION TECHNIQUE FOR THE AXIAL VECTOR CURRENT IN THE DECAY $\pi \to e\nu\gamma$. Konetschny, W.; Kummer, W. (Technische Hochschule, Vienna). Nuovo Cim.; 65A: 715-26(21 Feb 1970).

In two equivalent versions Brown and West have recently proposed a universal prescription for dealing with hard mesons in current algebra calculations of vertex functions. In a specific example, the axial form factor in the decay $\pi \to e\nu\gamma$, it is shown by an alternative calculation that consistency is only obtained if their original prescription is somewhat amended. (auth)

**15533** POSSIBILITY OF STRONG INTERACTIONS WITH A HADRONIC CURRENT FOR THE WEAKLY INTERACTING INTERMEDIATE VECTOR BOSON: THEORIES OF CP- AND T-VIOLATION IN ELECTROMAGNETISM, IN NEUTRAL K-DECAY AND IN VERY-HIGH-MOMENTUM-TRANSFER WEAK PROCESSES. Barshay, S. (Univ. of Copenhagen). Nuovo Cim.; 65A: 783-807 (21 Feb 1970).

An attempt is made to consider the origin of possible violations of CP- and T-invariance in the electromagnetic interactions of hadrons and in weak processes, including neutral-K decays, where the only so far established CP-violation occurs. The hypothesis is considered that the charged intermediate vector boson of weak interactions, $W^{\pm}$, has a strong interaction, quadratic in its field tensor and involving the divergence of a neutral hadronic vector current. If this current is odd under charge conjugation the interaction violates CP- and T-invariance. However, in the absence of the production of a real W pair, all C- and T-violating effects in a system of hadrons undergoing a strong or an electromagnetically induced reaction must originate through an electromagnetic interaction, or involve the W-pair interaction in third or higher order. The effects on weak interactions involving low energies and small momentum transfers between hadrons and also upon weak processes at energies and momentum transfers of the order of the mass of the W-particle are considered. Because the new interaction involves a current divergence, the neutron electric-dipole moment is not expected to be larger than about $10^{-23}$ e-cm. In a second model a neutral hadronic vector current is considered that is even under charge conjugation. The W-pair interaction now preserves CP- and T-invariance but, under the ansatz that the complete hadronic electromagnetic current is constructed from all of the neutral vector currents with zero strangeness that interact strongly, we are led to a CP- and T-noninvariance intrinsic to the electromagnetic interactions of hadrons. If the complete hadronic electromagnetic current has the same $SU_3$ transformation properties as the usual C-odd piece, then the W-pair interaction may transform as a linear combination of octet eighth and third components, introducing an $SU_3$ and isotopic spin breaking part into the strong-interaction itself. However, in a limiting fictitious world where exact $SU_3$ symmetry holds for the strong interactions both the W-pair interaction and the CP- and T-violating electromagnetic interaction vanish. The possibility of CP- and T-noninvariance intrinsic to both the W-pair interaction and the electromagnetic interaction of hadrons is considered. Some estimates are given for production cross sections for a $W^{\pm}$ pair in clashing beam experiments with available energy in excess of 30 GeV. (auth)

**15534** LEADING DIVERGENCES IN A MODEL OF THE WEAK INTERACTION. Terazawa, H. (Cornell Univ., Ithaca, N. Y.). Lett. Nuovo Cim.; 3: 143-5(29 Jan 1970).

A more realistic model, than that previously used, is given for a detailed analysis of the divergences of two different spinor particles $\Psi_1$ and $\Psi_2$ (with masses $m_1$ and $m_2$, respectively) interacting with a neutral vector boson. (J.F.P.)

**15535** ABSOLUTE DISTINCTION BETWEEN PARTICLES AND ANTIPARTICLES. Heiko, Lance (Instituto Politecnico Nacional, Mexico City). Rev. Mex. Fis.; 18: 373-8(1969).

The absolute distinction between particles and antiparticles by the interference of $K_S^0$ and $K_L^0$ into two pions is re-examined. We do not assume the experiment begins with $K^0$ or $\overline{K}^0$. Instead matter and anti-matter are defined operationally. This permits a comparison of the interference experiment performed terrestrially and on some distant world. A distinction can now be made from the behavior of the interference term between a world composed of matter and one of anti-matter. (auth)

**15536** NONLEPTONIC HYPERON DECAYS. Flamm, D. (Institut fuer Hochenergiephysik, Vienna). Acta Phys. Austr.; Suppl. 6, 91-123(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

Nonleptonic hyperon decays are studied in the quark model approach and in the current algebra approach. Both the soft-pion and hard-pion techniques are discussed. (L.B.S.)

**15537** LOW-ENERGY WEAK SINGLE-PION PRODUCTION BY CURRENT COMMUTATORS. Paver, N. (Univ., Trieste, Italy); Verzegnassi, C.; Radescu, E. E. Nuovo Cim.; 66A: 261-85(1 Mar 1970).

A description is given of the weak single-pion production process in the slow-pion region, based on current commutators, plus an extensive use of PCAC. The predictions obtained completely describe the s-wave and p-wave multipoles. (auth)

**15538** UNIFIED TREATMENT OF LEPTONS. Barut, A. O. (International Centre for Theoretical Physics, Trieste, Italy); Cordero, P.; Ghirardi, G. C. Nuovo Cim.; 66A: 36-46(1 Mar 1970).

In an attempt at a unified treatment of leptons it is shown that a wave equation based on the most general conserved-current operator for a vertex can describe all known leptons with their physical masses. The appearance of only three masses is implied by the general assumptions. The $O_{4,2}$ treatment of massive spin-½ particles is extended to massless particles, and a unified labelling of all leptonic states is found. The electromagnetic and weak interactions of leptons are then written in terms of the matrix elements of currents with their corresponding gauge transformations. (auth)

**15539** NEUTRINO ENERGY DENSITY OF THE UNIVERSE. Bandyopadhyay, P.; Chaudhuri, P. R. (Indian Statistical Inst., Calcutta). Nuovo Cim.; 66A: 238-42(1 Mar 1970).

An estimate of the neutrino energy density of the universe was made on the basis of the photon-neutrino coupling theory of weak interactions. It is found that, according to this theory, neutrino energy density is the same as the matter density in the steady-state universe. Finally some cosmological implications of this result were discussed. (auth)

**15540** ON THE LIFETIME OF $^3H_\Lambda$. Kudryavtsev, A. E. JETP Lett. (USSR) (Engl. Transl.); 10: 342-4(5 Dec 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 537-41(5 Dec 1969).

An estimate independent of previous assumptions is made for the lifetime of $\Lambda - H^3$. Plots of the probability for two-body decay are given. (J.F.P.)

## *Strong (General)*

*Refer also to abstracts 15561, 15632, and 15686.*

**15541** (INP-681, pp 211-41) VENEZIANO MODEL OF SCATTERING AMPLITUDE. Swiecki, M. (Institute of Nuclear Research, Warsaw (Poland)).

The Veneziano model is reviewed briefly. Important correlations among the particles are observed from which the starting point for bootstrap theory can be obtained. Meson–meson and baryon–meson scattering are considered. (J.F.P.)

**15542** (LAL-1220) INTRODUCTION TO REGGE POLES. Jauneau, L. (Ecole Polytechnique, Paris (France). Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). Jul 1969. 122p. Dep. CFSTI (U. S. Sales Only).

Topics covered are: Strong interactions; kinematics of two-body reactions; crossing symmetry and Mandelstam hypothesis; short review of the theory of analytic functions; poles, bound states and resonances; Regge poles in potential theory; Regge poles in high energy hadronic interactions; the simple Regge model vs experience. (auth)

**15543** NARROW-RESONANCE APPROXIMATION AS A NECESSARY CONDITION FOR NUCLEAR DEMOCRACY AND HADRON MASS SPECTRUM. Potupa, A. S. (Minsk Inst. of Physics). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Mat. Navuk; No. 5, 118-20(1969). (In Russian).

A model based on the combined use of a narrow-resonance approximation and averaging according to the multiplets with identical spin–parity Regge trajectories permits a description of the spectral regularities of hadrons. (tr-auth)

**15544** RISING REGGE TRAJECTORIES AND DYNAMICAL CALCULATIONS. II. Mandelstam, Stanley. Comments Nucl. Particle Phys.; 3: 147-54(Sep-Oct 1969).

A discussion is given of developments based on the Veneziano formula allowing an analytical solution for previous dynamical

calculations in high-energy physics based on indefinitely rising Regge trajectories in the Veneziano model. Other than the fundamental narrow-resonance approximation no further approximations need to be made. While the solution possesses ghost resonances with negative decay probabilities, it also has many attractive features especially that of leading in a natural way to quark-type models even though the system may not possess quarks as physical particles. (J.F.P.)

15545 ALGEBRAIZATION OF SOME DISPERSION SUM RULES. Fubini, S. (Massachusetts Inst. of Tech., Cambridge); Furlan, G. Lett. Nuovo Cim.; 3: 168-72(29 Jan 1970).

It is shown that the relation derived by Weinberg (Phys. Rev. Lett., 22: 1023(1969)) is the algebraic translation of a commutator property of axial charges, or, more precisely, that it results from the infinite-momentum frame saturation of the commutators of the SU(2) × SU(2) axial vector charges with themselves and with all the generators of the Poincaré group. (C.E.S.)

15546 PARA-FERMIONS AND COMPOSITE STRUCTURE. Pac, P. Y.; Jun, H. R. (Seoul National Univ.). J. Korean Phys. Soc.; 2: 33-5(Apr 1969).

It is shown that composite structures, which consist of p parafermions of order p, are ordinary fermions when p is (2n-1), and ordinary bosons when p is 2(2n-1), where n is a positive integer. (auth)

15547 DUALITY IN STRONG INTERACTION PHYSICS. Jacob, M. (CERN, Geneva). Acta Phys. Austr.; Suppl. 6, 215-76(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

An attempt is made to formulate a duality approach to strong interaction physics where Regge behavior and resonances are interlocked. This leads to the prominent features of a simple bootstrap scheme based on rising Regge trajectories and yields some general properties of two-body collision amplitudes. The Veneziano model is then introduced, which offers solutions exhibiting duality properties. It is shown how the Veneziano model yields simple expressions for meson-meson scattering where current algebra constraints together with broken SU(3) relations can be simply incorporated. A few remarks are made on the generalization to many-particle production and reactions among particles with spin. (L.B.S.)

15548 BOOTSTRAP OF INDEFINITELY RISING REGGE TRAJECTORIES. Dietz, K. (Univ., Bonn). Acta Phys. Austr.; Suppl. 6, 277-309(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The general properties of bootstraps of infinitely rising Regge trajectories are studied. After a short outline of the general ideas, the bootstrap of zero-width resonances is described, which is shown to have serious defects. Duality bootstraps of broad resonances are discussed. Under general circumstances it is found that the Regge-trajectory and the Regge-residuum function are asymptotically determined in a unique manner. A generalized interference model that is fully crossing symmetric and gives almost no restriction on the parameters of indefinitely rising Regge trajectories is discussed. The dual model is extended to the case of full crossing symmetry, considered $\pi\pi$ scattering as an example. (L.B.S.)

15549 $Z_3 = 0$ LIMIT IN THE $Q_1 = N + 1$, $Q_2 = 1$ SECTORS OF THE LEE MODEL. Tataru, O. L.; Uliu, F. S. (Univ. of Craiova, Rumania). Rev. Roum. Phys.; 14: 675-8(1969).

A brief outline is given of the treatment of the $q_1 = n + 1$, $q_2 = 1$ sectors of a modified Lee model by means of the LSZ formalism. The problem of the existence of bound states and the connection between the Lee model in this sector and the separable potential model is analyzed by imposing the $Z_3 = 0$ condition and discussing the consequences of the Levinson theory. (L.B.S.)

15550 ON THE HADRON–HADRON ELASTIC SCATTERING IN A GLAUBER QUARK MODEL. Cotaescu, I. (Univ. of Timisoara, Rumania); Stamatescu, I. O. Rev. Roum. Phys.; 14: 629-39(1969).

$p\bar{p}$, pp and $\pi p$ elastic cross sections were computed in the multiple scattering model of R. J. Glauber, assuming quark structure for hadrons and using only one parameter (none for $\pi p$). Gaussians and dipolar form factors are discussed. (auth)

15551 COMPILATION OF COUPLING CONSTANTS AND LOW-ENERGY PARAMETERS. Ebel, G.; Pilkuhn, H.; Steiner, F. (Univ., Karlsruhe, Ger.). Nucl. Phys.; B17: 1-26(1970).

Coupling constants and various low-energy parameters for elementary-particle reactions collected from recent publications are presented. The aim is to give a survey and to facilitate access to the original work in this field. (auth)

15552 LOCAL CURRENT ALGEBRA MODEL WITH LINEAR TRAJECTORIES. Leutwyler, H. (CERN, Geneva). Phys. Lett.; 31B: 214-15(16 Feb 1970).

A model is constructed that contains an infinite number of particles with arbitrarily high mass and spin corresponding to a family of linear Regge trajectories. The model does not contain states with space-like momentum and gives rise to local currents obeying the standard equal time commutation relations. The basic structure is reminiscent of the oscillator representation of the Veneziano model; in particular ghost states with negative norm occur. (auth)

## Strong (Baryon No. = 0)

*Refer also to abstracts 15548, 15588, and 15608.*

15553 (INP-681, pp 171-92) ON THE THEORY OF $\pi\pi$ INTERACTION. Kwiecinski, J. (Institute of Nuclear Physics, Krakow (Poland)).

A short review of results concerning the $\pi + \pi$ interaction which were obtained using the PCAC and current algebra techniques and within the context of finite-energy sum rules and the Veneziano model is given. (J.F.P.)

15554 (NYO-2262-TA-215) SPIN-TWO MESONS, THE STRESS TENSOR, AND A FIELD-SOURCE IDENTITY. II. COVARIANCE CONDITIONS AND CONSISTENCY REQUIREMENTS. Raman, K. (Brown Univ., Providence, R. I. Dept. of Physics). Dec 1969. 39p. Dep. CFSTI.

The constraints imposed by Lorentz covariance on a theory with a field-source identity are derived and discussed. It is shown that the field-source identity determines the parts of the singular terms in the stress-tensor equal-time commutation relations which are the most singular in the coupling strength g. It further requires that some of the singular terms be q-numbers. The constraints imposed on the field-dependence of the source $J_{\mu\nu}(x)$ by the field-source identity and the Lorentz covariance conditions are obtained. It is shown that as a consequence of some of these, the interaction term $g J_{\mu\nu}(x)$ must be nonlinear in the coupling strength g. (auth)

15555 (TID-25343) PHENOMENOLOGICAL CURRENT ALGEBRA VERTEX. Wise, Michael L. (Brandeis Univ., Waltham, Mass. Dept. of Physics). Jun 1969. Contract AT(30-1)-3178. 166p. Dep. CFSTI.

Thesis.

The most general vertex function determined by the current algebra is constructed. Though the vertex function of three vector currents is emphasized, the methods employed are readily generalized. It is found that the vertex function naturally separates into two parts, a "canonical" part and a "noncanonical" part. The origin of the possible breakdown of the Johnson–Low–Bjorken theorem is investigated and a generalized Bjorken theorem is presented. The methods developed are applied to the $\pi\rho A_1$ system. The decays $A_1 \to \rho\pi$ and $\rho \to \pi\pi$ are parameterized in a convenient manner. Since a realistic model may require an underlying fermion field, subtracted representations for the propagators are derived and the regularized Ward identities for the currents are investigated. It is concluded that whereas current algebra will greatly restrict the class of strong interaction models, additional dynamical information must be found to enable one to calculate the remaining undetermined scalar functions. (auth)

15556 BOOTSTRAP OF THE $\pi$ AND $\rho$ TRAJECTORIES FROM THE $\sigma\pi \to 3\pi$ VENEZIANO AMPLITUDE. Savoy, C. A. (Univ., Padua). Lett. Nuovo Cim.; 2: 870-2(21 Dec 1969).

Starting from the Bardakci-Ruegg five-point function, a Veneziano-type amplitude is constructed for the process $\sigma\pi \to 3\pi$. A bootstrap of the $\pi$ and $\rho$ trajectories is achieved in a completely dual model by combining two external particles, $\sigma\pi$ or $\pi\pi$, to obtain the amplitudes for the processes $\pi\pi \to \pi P$ and $\pi\sigma \to \pi R$, respectively, where P(R) is any meson lying on the leading $\pi(\rho)$ trajectory. (L.B.S.)

15557 QUANTUM NUMBERS OF THE $A_2$-MESON. Capasso, V. (Univ., Bari, Italy). Lett. Nuovo Cim.; 3: 83-7(15 Jan 1970).

It is shown that all the difficulties of the $A_2$ meson disappear if the new classification of strange particles proposed by Selleri is used. (L.B.S.)

15558 $\pi\pi$ SCATTERING, CURRENT ALGEBRA, AND THE VIRASORO MODEL. Montvay, I. (Roland Eoetvoes Univ., Budapest); Vesztergombi, G. Lett. Nuovo Cim.; 3: 77-82(15 Jan 1970).

The combinations of Virasoro amplitudes that satisfy the current algebra predictions for $\pi\pi$ scattering are examined. It is found that there exists an infinite number of Virasoro-type amplitudes satisfying the chiral constraints but possessing I = 2 resonances in the higher mass region. (L.B.S.)

**15559** RIGOROUS INEQUALITIES ON S AND P WAVES FOR $\pi-\pi$ SCATTERING. Auberson, G. (CEN, Saclay, France); Mahoux, G.; Brander, O.; Martin, A. Nuovo Cim.; 65A: 743-63 (21 Feb 1970).

Inequalities on the S and P pion–pion partial-wave amplitudes are obtained by combining crossing symmetry with positivity properties for general isospin mixtures. This set of inequalities can be used in particular to rule out models. For instance in the Iliopoulos model all solutions are excluded except the one of the type proposed by Weinberg. (auth)

**15560** ON THE POSITIVITY OF THE $\pi\pi$ RESONANCE WIDTHS IN THE VENEZIANO MODEL. Ghika, G.; Visinescu, M. (Inst. for Atomic Physics, Bucharest). Nuovo Cim.; 65A: 707-14 (21 Feb 1970).

The positivity of the partial width of the $\pi\pi$ resonances having low spin l (l = 0, 1, 2) in the Veneziano model is studied. It is also shown how one satellite-trajectory term can be added in order to obtain positive width for the $0^+$ partner of the f-meson and smaller widths for the resonances lying on the first daughter trajectory. (auth)

**15561** CONSISTENCY OF BROKEN CHIRAL SYMMETRY AND VENEZIANO MODELS. Csikor, F. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett.; 31B: 141-2(2 Feb 1970).

It is shown that the correct off-mass-shell Veneziano amplitude is not incompatible with the broken symmetry model of Gell-Mann, Oakes and Renner, contrary to the statement made by Cronin and Kang. (auth)

**15562** CHIRAL INVARIANCE, CONTACT INTERACTIONS, AND THE DECAY OF THE $\omega$-MESON. Alles, W. (Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna). Lett. Nuovo Cim.; 3: 163-7(29 Jan 1970).

Meson ($\omega$) decay is discussed using the formalism of SU(2) × SU(2) chiral-invariant Lagrangians in the tree diagram approximation. The total width and branching ratio for $\omega \rightarrow \pi^0 + \gamma$ decay are calculated. (J.F.P.)

**15563** VENEZIANO AMPLITUDES AS A CONSEQUENCE OF MEROMORPHY AND REGGE BEHAVIOR. Tiktopoulos, G. (Princeton Univ., N. J.). Phys. Lett.; 31B: 138-40(2 Feb 1970).

The Veneziano form for the scattering amplitude for $\pi^+\pi^-$ scattering is derived on the basis of the meromorphy approximation and a certain asymptotic property directly derived from Regge behavior. (L.B.S.)

**15564** THE $K_L^0-K_S^0$ MASS DIFFERENCE IN THE QUARK MODEL. Flamm, D.; Majerotto, W. (Institut fuer Hochenergiephysik, Vienna). Lett. Nuovo Cim.; 3: 139-42(29 Jan 1970).

A different approach within the quark model is considered for the $K_2^0-K_1^0$ mass difference. This approach is based on the $K^0-\overline{K}^0$ transition. The value of the mass difference is found to be 10.8 $(10)^{-12}$ MeV. It is noted that this value has the correct sign, but is too large due to the simplicity of the model. (J.F.P.)

**15565** SOME CONSEQUENCES OF THE RELATION OF $\pi\pi$ PARTIAL-WAVE AMPLITUDES TO SERIES OF STIELTJES. Common, A. K. (CERN, Geneva). Nuovo Cim.; 65A: 581-96 (21 Feb 1970).

Two consequences of the Stieltjes representation for $\pi-\pi$ partial-wave amplitudes $a_l(s)$, which holds for $0 \leq s < 4$ and certain charge states, are discussed. Firstly improved bounds for the total amplitude A(s,t) for these values of s for $-s < t < 0$ and $4-s < t < 4$ are obtained from the first few partial waves $a_l(s)$. Then from this same information upper and lower bounds to $a_l(s)$ are derived for all real $l > 2$. In proving these results it is shown that bounds obtained previously by Baker for the series of Stieltjes may be differentiated to give bounds to the derivatives of this series. (auth)

**15566** NUCLEON–ANTINUCLEON BOUND STATES. Patergnani, G. (Univ., Padua). Z. Phys.; 230: 317-28(1970).

A system of bound nucleon-antinucleon, with the quantum numbers of various scalar and pseudoscalar existing particles and resonances is studied with a Bethe Salpeter equation in the ladder approximation. The interaction is produced by $\pi$-mesons. The effect of a phenomenological vector interaction is also checked. The bound states are classified according to their isotopic spin, G parities, parities, nucleonic number, spin and masses. To obtain the experimental value for the coupling constant $g_{N\overline{N}\pi}$ the used model requires for a cut off values between 0.3 to 5 nucleonic masses. The effect of the vector interaction is always attractive. (auth)

**15567** EQUAL TIME COMMUTATORS, SUM RULES, AND LOW ENERGY PION PHYSICS. Furlan, G. (Univ., Trieste, Italy). Acta Phys. Austr.; Suppl. 6, 52-90(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

A unified treatment is given of the dispersive sum rules and low energy limits arising from the saturation of a charge commutator in a general reference frame. In particular it is shown that very simple predictions are obtained for physical pion amplitudes in terms of equal time commutators plus a completeness sum. The treatment is then generalized to pions of any momentum. (L.B.S.)

**15568** MODIFIED QUARK MODELS. Horn, D. (Tel Aviv Univ., Israel). Acta Phys. Austr.; Suppl. 6, 157-66(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The implications of the splitting of the $A_2$ resonance are discussed. It leads to theories where either a $1^{-+}$ or another $2^{++}$ resonance is present. The $1^{-+}$ is included in the Gell-Mann–Zweig O(4) scheme, which is described in detail. An additional $2^{++}$ can be provided by many models, one of which—the giant quark model—is briefly described. (auth)

**15569** CONSTRUCTION OF FUNCTIONS THAT SATISFY CROSSING SYMMETRY AND UNITARITY. Kupsch, J. (CERN, Geneva). Nuovo Cim.; 66A: 202-16(1 Mar 1970).

The $\pi^0\pi^0$ amplitudes with arbitrary polynomial increase in the double spectral region are constructed that satisfy crossing symmetry and the inelastic-unitarity bounds $\text{Im } f_l(s) - |f_l(s)|^2 \geq 0$, l = 0, 1, 2, . . . , for all $s > 4$. Exact elastic unitarity is then obtained by an interation procedure which was proposed by Mandelstam and discussed in detail by Atkinson. The resulting amplitude which fulfils crossing symmetry, elastic unitarity and the unitarity bounds in the inelastic region is the sum of Regge terms with bounded trajectories and a once-subtracted Mandelstam representation which guarantees the unitarity of the whole amplitude. (auth)

**15570** TEST OF DUALITY SUM RULES FOR MESONS. Auvil, P. R.; Halzen, F. (CERN, Geneva). Nuovo Cim.; 66A: 293-8(1 Mar 1970).

Implications of duality and exchange degeneracy in pseudoscalar-pseudoscalar scattering are considered. Tests of these results at t = 0, which are independent of detailed dynamical assumptions for the Regge-residue functions, are proposed and found to be in agreement with experiment. (auth)

**15571** $\pi\pi$, $\pi K$ AND KK VENEZIANO AMPLITUDES AND CURRENT ALGEBRA. Osborn, Hugh (Queen Mary Coll., London). Nucl. Phys.; B17: 141-67(1970).

The Veneziano amplitudes for $\pi\pi \rightarrow \pi\pi$ and $\pi K \rightarrow \pi K$ are used to extrapolate the results of current algebra from the soft pion or soft kaon limit when any pair of mesons are taken off the mass shell. The SU(3) × SU(3) symmetry breaking theory of Gell-Mann, Oakes and Renner, is assumed and predictions made for the normalization of the Veneziano amplitudes and resonance decay widths, the magnitudes of matrix elements of current algebra $\sigma$ terms, the value of the symmetry breaking parameter c, $F_K/F_\pi$. Expressions are found for the $K_{l3}$ form factors from the Veneziano amplitudes for $\pi K \rightarrow \pi K$ and $\pi K \rightarrow \pi K_A$. It is shown that current algebra cannot be similarly applied to the Veneziano amplitude for $KK \rightarrow KK$. (auth)

**15572** GENERALIZED VENEZIANO MODEL FOR n PARTICLES, TRAJECTORIES WITH SIGNATURE. Koba, Z.; Nielsen, H. B. (Univ. of Copenhagen). Nucl. Phys.; B17: 206-20(1970).

Requiring definite signatures of all the parent and daughter trajectories involved in the n-meson Veneziano amplitude, a set of constraints are derived on the parent trajectories, which is a generalization of Veneziano's relation, $\alpha_s + \alpha_t + \alpha_u = 2$. (The mass formulas implied by them are compared with experimental values in the case n = 5.) The signatures to be ascribed to parent trajectories have to fulfil certain consistency conditions. (auth)

**15573** HARD-PION APPROACH TO $\omega$ DECAYS. Micu, L.; Visinescu, M. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 651-8(1969).

Using the hard pion technique the ratios $\Gamma(\omega \rightarrow \pi\gamma)/\Gamma(\omega \rightarrow 3\pi)$ and $\Gamma(\omega \rightarrow \pi\gamma)/\Gamma(\pi^0 \rightarrow 2\gamma)$ are evaluated. The results are compared with those obtained from current algebra in the soft pion limit and with the vector meson pole model. (auth)

**15574** ANNUAL REVIEW OF NUCLEAR SCIENCE. VOLUME 19. Segre, Emilio; Grover, J. Robb; Noyes, H. Pierre (eds.). Palo Alto, Calif.; Annual Reviews, Inc. (1969). 640p. $8.50.

Separate abstracts are prepared for the eleven papers included. (C.E.S.)

*For abstracts of individual papers see: 14029, 14373, 14463, 15575, 15595, 15616, and 15974–15978.*

**15575** BOSON RESONANCES. Butterworth, I. (Rutherford High Energy Lab., Chilton, Eng. Imperial Coll. of Science and Tech., London). Ann. Rev. Nucl. Sci.; 19: 179-300(1969).

The review of boson resonances covers the existence of higher representation mesons, pseudoscalar, vector, axial-vector, and scalar mesons, the $2^+$ nonet, survey of positive-parity mesons,

the F′ meson, heavy nonstrange mesons below the $\bar{N}N$ threshold (1600 to 1880 MeV), and mesons above the nucleon–antinucleon threshold. (163 references) (J.F.P.)

**15576** PROPERTIES OF UNSTABLE PARTICLES. Jersak, Jiri (Univ., Bern). Helv. Phys. Acta; 43: 93-8(16 Feb 1970).

A condition is postulated which determines possible decay laws of unstable particles. These decay laws are interpreted in terms of single and multiple poles on the second sheet. (auth)

**15577** CURRENTS AND MESONS. Sakurai, J. J. Chicago Lectures in Physics. Chicago; University of Chicago Press (1969). 171p.

The discussion of currents and mesons covers a review of SU(3), divergence conditions and current commutation relations, vector meson universality, PCAC and the Goldberger–Treiman relation, and soft-pion processes. (J.F.P.)

## *Strong (Baryon No. = 1)*

*Refer also to abstracts 15486, 15497, 15498, 15686, and 16004.*

**15578** (COO-264-529) REGGE CUTS AND THE VENEZIANO MODEL IN BACKWARD $\pi N$ SCATTERING. Amann, R. F. (Chicago Univ., Ill.). Dec 1969. Contract AT(11-1)-264. 36p. (EFI-69-100). Dep. CFSTI.

The Reggeized absorptive cut is included in three Regge pole (the $\Delta$, $N_\alpha$, $N_\gamma$) fits to backward $\pi N \to N\pi$ differential cross sections. The overall framework of the Veneziano model is used and successful fits are found with smooth one-parameter residues. The cuts remove the Veneziano model's contradictions with experiment, are essentially parameterless and are definitely non-negligible. Methods to verify their presence are discussed. The usual difficulty in extrapolating to the $\Delta$ mass (too small a width) remains unresolved. Possible explanations of this problem are discussed. (auth)

**15579** (INP-681, pp 193-210) CURRENT ALGEBRA ON THE MASS SHELL, DISPERSION RELATIONS, AND PION–NUCLEON SCATTERING. De Rujula, Alvaro (European Organization for Nuclear Research, Geneva (Switzerland)).

The presentation of a method combining algebraic and analytic techniques in pion processes is given. Current algebra and the partial conservation of the weak axial current are used in the calculation of subtractions to fixed-momentum-transfer invariant-amplitude dispersion relations. A proposal is made of a way to use the PCAC and current algebra information without having to go off the pion mass shell. Also an application is made to pion–nucleon scattering, where the subtractions to invariant amplitude dispersion relations are estimated, and a calculation of low-energy phase shifts is made and compared to experiment. (J.F.P.)

**15580** (JINR-P2-4883) ON THE VIRASORO MODEL FOR $\pi N$ SCATTERING. Zhuravlev, V. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1970. 13p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The $\pi N$-scattering in Virasoro model is considered. The obtained results are compared with experiment and the Veneziano model predictions. (auth)

**15581** (JINR-P3-4783) FUNDAMENTAL ELECTROMAGNETIC PROPERTIES OF A NEUTRON: ELECTRICAL CHARGE, ELECTRICAL DIPOLE MOMENT, ELECTROMAGNETIC FORM FACTORS, POLARIZABILITY, (n–e) INTERACTION. Aleksandrov, Yu. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Reactions). 1969. 54p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Experimental papers devoted to fundamental electromagnetic properties of a neutron, such as: electric charge, electric dipole moment, electromagnetic form factors, polarizability, and (n–e)-interaction are reviewed. (auth)

**15582** NONRESONANT EXPLANATION FOR $K\pi\pi$ MASS ENHANCEMENT AT 1300 MeV IN 4.6- AND 5.0-GeV/c $K^-$ MESON PROTON INTERACTIONS. Wolfe, Richard Harry. Syracuse, N. Y.; Syracuse Univ. (1968). 96p.

Thesis.

In recent high energy interactions involving mesons incident on a hydrogen target, many of the final states contain a proton. Events whose final state proton did not result from the decay of a nucleon resonance are typified by production with low momentum transfer to the proton. Such correlation is usually associated with meson resonance production via one-particle exchange mechanisms, resulting in quasi-two body production. However, in an investigation of the four body final state $pK\pi\pi$, a sharper than usual momentum transfer distribution was found to be correlated with a large low $K\pi\pi$ mass peak for those events containing either a $K^*(890)$ or $\rho(748)$ meson. It is shown that exchange diagrams involving diffraction scattering at lower vertex, after the work of R. Deck and others, can explain the features of this mass peak as kinematical, without invoking the existence of a resonance in the 1200 to 1500 MeV range. (Diss. Abstr.)

**15583** TWO-BODY PROCESSES AND REGGE-POLE MODEL. Murro, O. (Univ., Bari, Italy); Selleri, F. Lett. Nuovo Cim.; 2: 863-9(21 Dec 1969).

The prediction that processes in which strange Regge trajectories are exchanged should decrease with $P_L$ ($P_L$ = laboratory momentum) faster than processes in which the $\rho$-trajectory is exchanged is examined. The laboratory momentum-dependences of the total cross sections for the following strangeness-exchange reactions are presented: $\pi^+p \to K^+\Sigma^+$, $K^-p \to \pi^-\Sigma^-$, $\pi^-p \to K^0Y^0$, $K^-p \to \pi^-Y^{*+}(1385)$, and $\pi^+p \to K^+Y^{*+}(1385)$. These reactions are shown to decrease with $P_L$ slower or like $\sigma(\pi^0 n)$, which contradicts the qualitative Regge-pole picture. (L.B.S.)

**15584** PARTIAL WIDTHS FOR THE DECAY OF T = 3/2 NUCLEON STATES INTO $\Sigma^+K^+$. Feuerbacher, J. L.; Holladay, W. G. (Vanderbilt Univ., Nashville). Nucl. Phys.; B16: 85-92(1970).

Reduced partial widths, partial widths, and branching fractions for the decay of T = 3/2 nucleon resonances into $\Sigma^+K^+$ were determined by fitting differential cross section and average polarization data between threshold and 2 GeV c.m. energy in the process $\pi^+p \to \Sigma^+K^+$. Resonance contributions were taken to have the Breit-Wigner form and pole terms in the crossed channels were used to represent the non-resonant background. The resonances $S_{31}(1635)$, $P_{31}(1934)$, $P_{33}(1236)$, $P_{33}(1688)$, $D_{33}(1691)$, $D_{35}(1954)$, $F_{35}(1913)$ and $F_{37}(1946)$ were included in the model. Fits to the data are obtained by varying the pole and resonance strengths. The partial width of the $F_{37}(1946)$ into the $\Sigma K$ channel is compared with values calculated by several models. (auth)

**15585** $K^-p$ AND $\bar{p}p$ ELASTIC SCATTERING AND THE SHADOW OF GENERALIZED ANNIHILATION PROCESSES. Henzi, R. (Univ. of California, Los Angeles); Kotanski, A.; Morgan, D.; Van Hove, L. Nucl. Phys.; B16: 1-34(1970).

The differences between the high-energy total cross sections and elastic scatterings of $K^-p$ and $\bar{p}p$ and their counterparts under crossing, $K^+p$ or pp, are analyzed in terms of the inelastic channels open for the former and closed for the latter system. For $\bar{p}p$ these channels are mainly baryon annihilation. For $K^-p$ the concept of hypercharge annihilation $K^-p \to$ hypercharge-zero particles (mainly one Y = 0 hyperon and Y = 0 mesons) and a vaguer notion of charge annihilation are introduced and it is proposed that these generalized annihilation channels are the main ones open to $K^-p$ and closed to $K^+p$. The contribution of the generalized annihilation processes to the overlap function of the overall collision is derived from the $\sigma_T$ and $d\sigma_{el}/dt$ data, using various simple model assumptions. The results, which are insensitive to the latter, predict the total annihilation cross sections and their high-energy dependence, as well as the range of the annihilation processes. The annihilation cross sections compare well with the few measured values. The annihilation ranges are predicted to be equal for $K^-p$ and $\bar{p}p$, with a value close to the range of elastic scattering of $\bar{p}p$ and pp. The elastic range of Kp is smaller by about a factor two. (auth)

**15586** ETA PRODUCTION BY PIONS. Carreras, B. (Daresbury Nuclear Physics Lab., Eng.); Donnachie, A. Nucl. Phys.; B16: 35-45(1970).

The generalized interference model is applied to the process of $\eta$ production by pions. The model is shown to give a good description of this process at all energies. (auth)

**15587** DOUBLE-PERIPHERAL MODEL AND THE FOUR-MOMENTUM-TRANSFER DISTRIBUTIONS IN THE REACTION $K^+p \to K^+\pi^-N^{*++}$ AT 5 GeV/c INCOMING MOMENTUM. Bialas, A. (CERN, Geneva); Bassompierre, G.; Eskreys, A.; (and others). Nucl. Phys.; B16: 178-90(1970).

The reaction $K^+p \to K^+\pi^-N^{*++}$ at 5 GeV/c $K^+$ primary momentum was analyzed from the point of view of the double-peripheral model. The distributions of four-momentum transfers $t'pN^*$ and $t'KK$ ($t' = t - t_{min}$) were studied as functions of the masses of the $N^{*++}\pi^-$ and $K^+\pi^-$ systems. It was found that the observed correlations cannot be explained adequately by the present version of the Chan-Loskiewicz-Allison model. The disagreement is particularly striking for the low $N^{*++}\pi^-$ mass region, where the data show peripheral production of the $N^{*++}$, contrary to the prediction of the model. The implications of the results for the double peripheral model are discussed. (auth)

**15588** ANTIPROTON–DEUTERON SCATTERING IN IMPULSE APPROXIMATION. D'yakonov, I. A.; Nemirovskii, P. E.; Khripunov, V. I. (Inst. of Engineering-Physics, Moscow). Yadern. Fiz.; 10: 1166-77(1969). (In Russian).

The method is developed for the calculation of antinucleon–deuteron elastic scattering cross section and the total cross section of antinucleon–deuteron interaction in the impulse approximation for the energy of incident antinucleon about 25 to 100 MeV. The complex antinucleon–nucleon potential for the model by Nemirovskii et al., including tensor forces, is used. Results of calculation of the antinucleon–deuteron cross sections are compared with corresponding antinucleon–nucleon cross sections for equivalent energies. It is shown that there is no additivity of the antinucleon–nucleon cross sections in the antinucleon–deuteron problem. (auth)

**15589** REGGE AMPLITUDES AND LOW AND INTERMEDIATE ENERGY $\pi$-N SCATTERING. Letessier, J.; Tounsi, A. (Institut de Physique Nucleaire, Paris). Nuovo Cim.; 65A: 808-19(21 Feb 1970).

The N/D analysis of Regge-type amplitudes, carried out in a previous work for $\pi$N scattering, is pursued in a more realistic way. The P, P', $\rho$, N, $\Delta$ Regge trajectories are taken into account. Second-sheet poles are found, the positions of which are close to the observed resonances. Comparison is made with results obtained in Argand-diagram analysis. Moreover, the differential cross sections are calculated and are found to be in remarkable agreement with the experimental data at relatively low energies. (auth)

**15590** OFF-MASS-SHELL APPROACH TO BARYON RESONANCES. Sugawara, Masao (Purdue Univ., Lafayette, Ind.). Acta Phys. Austr.; Suppl. 6, 310-49(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The off-mass-shell continuation of the decay matrix element in which a baryon resonance decays into another baryon resonance with the emission of a single pion, kaon, or $\eta$-meson is studied. The off-mass shell self-consisting conditions are derived, and the baryon resonances are studied in terms of these self-consistency conditions. (L.B.S.)

**15591** AMBIGUITIES IN REGGE ANALYSES AND COMPARISON WITH PHASE SHIFTS. Daum, C.; Michael, C.; Schmid, C. (CERN, Geneva). Phys. Lett.; 31B: 222-5(16 Feb 1970).

A simple rotation in the flip non-flip plane is discussed, which is undetermined in conventional Regge fits (i.e., those without FESR), and which thus affects the conclusions about mechanism choosing at $\alpha = 0$. Our t independent effective pole analysis of $K^+p$ elastic scattering naturally continues down to $p_{Lab} = 1.45$ GeV/c, where a rotation invariant comparison with the $K^+p$ phase shifts is made. (auth)

**15592** APPLICATION OF A REGGEIZED MULTIPERIPHERAL MODEL TO $\pi^-p$ INTERACTIONS AT 11 GeV/c. Caso, C. (Univ., Genoa. Istituto Nazionale di Fisica Nucleare, Genoa); Conte, F.; Tomasini, G.; (and others). Nuovo Cim.; 66A: 11-35(1 Mar 1970).

The modified multi-Regge model by Chan, Łoskiewicz and Allison (CLA) to calculate one-particle distributions of transverse and longitudinal momenta, $p_t$ and $p_l^*$, and invariant-mass distributions of the reactions $\pi^-p \to N + (n-1)\pi$ with multiplicities n ranging from 3 to 7 and an incident momentum of 11 GeV/c is used. The model is applied in a way that allows a distinction to be made between differently charged pions. In order to account for the experimentally observed neutral pions in the forward direction, the $\rho$ is taken for the trajectory with G-parity + 1 and not the Pomeron used A comparison between the multi-Regge calculations and the experiment shows a good overall agreement. A remarkable feature of the reaction $\pi^-p \to p\pi^+\pi^-\pi^-\pi^0$ is that almost no $\Delta^{++}$ production can be observed, when the prediction of the multi-Regge model is taken as a representation of the background in the $p\pi^+$ mass plot. However, this does not necessarily mean that no $\Delta^{++}$ production is present, but it might be an indication of the local duality now under discussion. (auth)

**15593** THE $\Omega^-$ AS A K$\Xi$ BOUND STATE IN BROKEN SU(3) YUKAWA-TYPE LAGRANGIAN FIELD THEORY. Redei, L. B. (Umea Univ., Sweden). Nucl. Phys.; B17: 38-44(1970).

In a previous article the mass of the $N_{\frac{3}{2}}^*$ resonance was calculated by assuming pseudoscalar Yukawa coupling and summing those terms in the perturbation expansion of the S-matrix which do not contain more than two mesons and a nucleon in their intermediate state. Fitting the pion-nucleon coupling constant to the scattering length $g^2/4\pi = 23.25$, $M_{N^*} = 1368$ MeV was obtained. Low energy K$\Xi$ scattering by the same method is treated. Yukawa coupling is assumed between the octet baryons and the pseudoscalar octet mesons and SU(3) relations for the coupling constants while using the physical values for the masses. The experimental value $\alpha = 0.75$ is used for the F/D mixing parameter and $g^2/4\pi = 23.25$ for the pion-nucleon coupling constant as obtained previously by fitting the model to the pion-nucleon scattering length. There are no additional parameters. The $\Omega^-$ is obtained as a K$\Xi$ bound state with $M_{\Omega^-} = 1796$ MeV to be compared with experimental value of 1675 MeV. (auth)

**15594** K$\pi$ PHASE SHIFTS FROM $K_{l3}$ DECAY. Pham, Xuan Yem; Sazdjian, Hagop (CNRS, Paris). Nucl. Phys.; B17: 27-37(1970).

The S- and P-wave K$\pi$ phase shifts which are connected to the $K_{l3}$ form factors by the dispersion relation approach are discussed. Also the $K^*$ (890) resonance dominates the K$\pi$ P-wave. It is found that plausible phase shifts can be obtained only when $|\xi_0| < 0.5$ and $\beta \approx 10^{-2}$ (where $\xi_0$ and $\beta$ are defined by $f_-(s)/f_+(s) = \xi(s) = \xi_0 + \beta s/m_\pi^2$). An S-wave K$\pi$ interaction would be quite unusual if $\xi(s)$ is negative and large (say $\xi < -0.5$). Existence of the $\kappa$-meson seems to be improbable if $\xi < -0.3$. The case of the zeros of the form factors is also discussed. (auth)

**15595** PION–NUCLEON INTERACTIONS. Moorhouse, R. G. (Univ. of Glasgow). Ann. Rev. Nucl. Sci.; 19: 301-66(1969).

Meson ($\pi$)-nucleon interactions are reviewed covering low-energy constants, dispersion relations, and sum rules, partial-wave amplitude analysis and resonances, high-energy scattering, and dynamics. (152 references) (J.F.P.)

**15596** SOME ASPECTS OF THE INTERPRETATION OF QUASI-TWO-BODY REACTIONS WITH INCIDENT PIONS ON PROTONS WITHIN REGGE-TYPE MODELS. Andreescu, Ileana (Univ., Bucharest). Stud. Cercet. Fiz.; 21: 777-93(1969). (In Rumanian).

Behavior of the diffraction maximum, settlement of exchange poles, differential cross sections of quasi-two-body reactions, and theoretical interpretation of the energy dependence of the diffraction maximum are discussed. (auth)

## *Strong (Baryon No. ≥ 2)*

*Refer also to abstract 15862.*

**15597** (INP-681, pp 59-80) ON THE BINDING ENERGY OF A $\lambda$ PARTICLE IN NUCLEAR MATTER. Dabrowski, J. (Institute of Nuclear Research, Warsaw (Poland). Warsaw Univ. (Poland). Inst. for Theoretical Physics).

The binding energy of hyperon ($\lambda$) interactions with nucleons is studied. The binding energy is calculated using Brueckner-type calculations. The independent-pair approximation of the Brueckner theory is also discussed. (J.F.P.)

**15598** (LA-DC-10638) ELASTIC CHANNEL IN NUCLEON-DEUTERON SCATTERING. Seagrave, John D. (Los Alamos Scientific Lab., N. Mex.). [1969]. Contract W-7405-eng-36. 118p. (CONF-690710-4). Dep. CFSTI.

From International Conference on the Three-Body Problem, Birmingham, England.

The final n-d scattering lengths are given as $^4a = 6.13 \pm 0.04$ fm and $^2a = 0.15 \pm 0.05$ fm; the experimental bases for these results are described. The difficulty of extracting the s-wave phase shifts at low energies is illustrated, and preliminary error limits at 0.1 and 0.2 MeV are given. Cubic spline data fitting is outlined mathematically and illustrated graphically, and applied to the representation of n-p and n-d total cross sections for energy up to 1 GeV; the n-n difference between the n-d and n-p spline fits is also presented. Tables of the spline representation of the n-d total cross section, the numerical data, and of p-d total cross sections at high energy are provided. The present status of phase-shift analysis is found unsatisfactory, though both experiment and theory appear adequate; an energy-dependent analysis is called for. The suggestion that there may be undetected fluctuations in the n-p and n-d total cross sections is examined in detail, with negative results. Ninety-three sets of differential cross sections between 0.1 and 2000 MeV are presented in a uniform, computer-generated, graphical compilation, using cubic spline fitting. The spline fits are represented in oblique three-parameter displays in five logarithmic decades of energy. The 100–1000 MeV decade is found wanting of adequate experimental coverage. New Los Alamos n-d data at 5.55, 7, 8, 9, 18.55, 20.5, and 23 MeV are presented, and the extensive unpublished p-d data between 1 and 11.5 MeV from Rice and Wisconsin are included in the compilation. Unpublished or inaccessible high-energy small-angle or isolated cross sections are also tabulated. New Los Alamos results for n-t polarization at 22 MeV are presented, and the development of a superconducting solenoid for neutron spin precession, and of "supercollimation" of negative ion beams are illustrated. The capabilities of the Los Alamos 100–800 MeV "Meson Factory" (LAMPF) under construction are outlined, and the present status of planning for experiments in the few-nucleon field is discussed. (165 references) (auth)

**15599** (ORNL-tr-2258) MECHANISM OF INTERACTION OF HIGH AND ULTRA-HIGH ENERGY PARTICLES WITH ATOMIC NUCLEI. NEW TYPES OF ELEMENTARY PARTICLE INTER-

ACTIONS. Barashenkov, V. S.; Gudima, K. K.; Eliseev, S. M.; Il'inov, A. S.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated for Oak Ridge National Lab., Tenn., from report JINR-P2-4662. 10p. Dep. CFSTI.

This article was previously abstracted from the original language and appears in NSA as 23: 51951. (C.E.S.)

**15600** (ORNL-tr-2266) PRODUCTION OF NEGATIVE PARTICLES BY PROTONS WITH ENERGIES OF UP TO 70 GeV. Bushnin, Yu. B.; Gorin, Yu. P.; Denisov, S. P.; (and others) (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). Translated for Oak Ridge National Lab., Tenn., from report IFVE-SEF-69-18. 13p. Dep. CFSTI.

This article was previously abstracted from the original language and appeared in NSA as 23: 51849. (C.E.S.)

**15601** NUCLEON-NUCLEON BREMSSTRAHLUNG. Hussain, Afzaal. Rochester, N. Y.; Univ. of Rochester (1969). 100p.

Thesis.

Nucleon-nucleon bremsstrahlung was calculated with the idea that this process could be used to investigate the off-shell properties of the two-nucleon (in nuclei) elastic potentials. It was thought that the high-energy end of the photon spectrum would be the region where the nucleons would be most off energy shell and accordingly the final states were restricted to be S-states. Standard nuclear theory techniques in configuration space and the Siegert theorem were used. For p-p-$\gamma$ all important transitions to the final state $^1S_0$ were considered, while for n-p-$\gamma$ the final states $^1S_0$ and coupled $^3S_1 + {}^3D_1$ were considered. The Hamada-Johnston potential and the two new potentials, one having hard cores and the other soft core were employed. Using these potentials, wave functions for the various partial waves was obtained by numerically integrating the Schrödinger equation. The hard core wave functions were obtained by integrating from outside in, while the soft core wave functions required more care and were integrated from inside out. Since continuum wave functions are involved in the radial matrix elements a new method was developed which ensures both the convergence of the radial integrals as well as the validity of the long wavelength limit approximation. The results show that the off-shell differences between the potentials are most pronounced at the high energy end of the photon spectrum as expected. Therefore, nucleon-nucleon bremsstrahlung can be used as a means of testing potentials provided one is sensitive to the hard photons in the process. Comparisons with current experiments and theories are made. Some potential testing experiments are proposed which may be sensitive to high energy end of the photon spectrum in the near future. (Diss. Abstr.)

**15602** REGGE TRAJECTORY FOR THE DI-BARYON SYSTEM. Libby, L. M. (Univ. of Colorado, Boulder); Predazzi, E. Lett. Nuovo Cim.; 2: 881-4(21 Dec 1969).

Evidence is presented from several different experiments which suggest a Regge trajectory for the system of two baryons. The masses of the observed enhancements of the di-baryon system and the kind of experiment in which each was observed are given. (L.B.S.)

**15603** DIFFRACTION DISSOCIATION MECHANISM FOR HEAVY-TRIPLET PRODUCTION. Friedlaender, E. M. (Inst. of Atomic Physics, Bucharest). Lett. Nuovo Cim.; 3: 71-3 (15 Jan 1970).

Evidence has been presented for the occurrence deep underground of penetrating strongly interacting particles, correlated with high-energy muons, but lagging behind the latter's arrival times with typical delays of about 10 nanoseconds. A tentative interpretation is given of the delayed particles as members of a heavy fundamental triplet arising from the dissociation of very-high-energy cosmic-ray protons in collisions with atmospheric nuclei. Two questions are considered within the framework of the diffraction dissociation mechanism: how the very frequent occurrence of the hypothetical triplets be reconciled with the steeply falling cosmic-ray spectrum, and how the frequently occurring heavy singly charged particles have thus far escaped detection in spectrometric measurements. (L.B.S.)

**15604** BINDING ENERGY OF A A PARTICLE IN NUCLEAR MATTER WITH TENSOR AN INTERACTION. Dabrowski, J. (Univ. of Warsaw); Hassan, M. Y. M. Phys. Lett.; 31B: 103-5 (2 Feb 1970).

The tensor component in the modified Harndon and Tang AN potential (MHT) is found to increase the binding of a A particle in nuclear matter by about 5 MeV. A comparison with a pure central AN potential of similar low energy Ap scattering parameters as the MHT potential gives about 2 MeV for the tensor suppression effect. (auth)

**15605** BARYON RESONANCES IN NUCLEI: MAGNETIC MOMENTS OF THE DEUTERON. Arenhoevel, H. (Max-Planck-Institut fuer Chemie, Mainz. Univ., Frankfurt am Main); Danos, M.; Williams, H. T. Phys. Lett.; 31B: 109-12(2 Feb 1970).

Baryon resonance admixtures to the p-n system have been calculated, as well as their effect on the static and transition magnetic moments of the deuteron. (auth)

**15606** S- AND P-WAVE EFFECTIVE RANGE PARAMETERS FOR THE NUCLEON-NUCLEON INTERACTION. Sher, Michael Stephen. East Lansing, Mich.; Michigan State Univ. (1969). 105p.

Thesis.

A two parameter description for each of the low-energy proton-proton $^3P$ phase shifts is justified and used to perform the first comprehensive analysis of all the proton-proton scattering data below 27.6 MeV. Effective range parameters for the $^1S_0$ and $^3P$ states are determined. The analysis reveals several inconsistencies among the data below 10 MeV. The importance of the central, tensor, and spin-orbit P-wave parameters in any low energy analyses is pointed out, the ranges of these parameters are determined. Low energy magnetic and vacuum polarization effects in the proton-proton interaction are investigated. The magnetic amplitudes are found to contribute negligibly at these energies and the vacuum polarization effect is shown to be present and with a strength $1.053 \pm .090$ times its theoretical value. Finite core, hard core, and soft core potentials for the $^1S_0$ state have been found, each of which has a smooth radial dependence which avoids the large discontinuities of presently popular potentials. The nuclear potentials each fit equally the proton-proton scattering length and the same set of $^1S_0$ phase shifts, and produce very similar neutron-neutron scattering lengths. Finite structure effects of the nucleon charge and magnetic moment distributions are examined and are shown, under the assumption of charge-symmetry, to produce a change in the neutron-neutron scattering length of +.44 F. (Diss. Abstr.)

**15607** COMPOSITE PARTICLE COLLISIONS IN THE NON-RELATIVISTIC THREE-BODY THEORY. Sandhas, Werner (Univ., Bonn). Acta Phys. Austr.; Suppl. 6, 454-84(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

A method is described that reduces the three-body collision problem to two-particle equations effective potentials. The method is generalized for the n-body case. The treatment shows how perturbation theory can be applied to strong interaction multiparticle problems, namely, by an iterative determination of the effective potentials. (L.B.S.)

**15608** MODEL FOR THE POMERANCHUK TERMS. Greco, M. (CNEN, Frascati, Italy). Phys. Lett.; 31B: 216-21(16 Feb 1970).

A model for all the Pomeranchuk terms is constructed by taking into account some general properties associated to the leading vacuum singularity. It gives a very good description of the $p\bar{p}$, pp total and differential cross sections and provides an accurate determination of the Pomeranchuk parameters. (auth)

**15609** ELASTIC SCATTERING OF LOW-ENERGY PIONS BY ALPHA PARTICLES. Harun-Ar Rashid, A. M.; Samaranayake, V. K. (International Centre for Theoretical Physics, Trieste, Italy). Nucl. Phys.; B17: 189-205(1970).

The low-energy pion-alpha-particle elastic scattering is investigated using Schwinger's variational expression for the T-matrix. The method allows double scattering effects to be evaluated in a simple way. The results of the calculation are compared with the available experimental data. (auth)

**15610** PERTURBATION SOLUTION IN A LAPLACE REPRESENTATION OF THE SCHROEDINGER EQUATION FOR pp SCATTERING. Almstroem, H. (Royal Inst. of Tech., Stockholm). Nuovo Cim.; 66A: 286-92(1 Mar 1970).

A differential equation is obtained for $F_L(k)$ from which an integral equation can be obtained. Iterating this equation $F_L(k)$ expanded as a power series in the coupling constants is obtained. The case $\sigma(a) = g\delta(a-c)$ is treated explicitly and it is shown that when $c \to 0$ the perturbation terms can be added up and the solution approaches the Coulomb solution for $V(r) = (b + g)/r$. (auth)

# Particle Invariance Principles and Symmetries

## General

*Refer also to abstract 15653.*

**15611** APPLICATIONS OF GROUP THEORY IN QUANTUM MECHANICS. Petrashen, M. I.; Trifonov, E. D. Cambridge, Mass.; Massachusetts Institute of Technology Press (1969). 322p. $12.00.

Translation of Primeneniye Teorii Grupp v Kvantovoi Mekhanike by S. Chomet.

The theory of groups and matrix representations is fully developed, and the fundamental relation between the irreducible representations of the invariance group of a Hamiltonian and the eigenvalue degeneracy is obtained. This theory is applied to point and space groups as applied to the electronic and vibrational states of molecules and crystals respectively, continuous rotation groups for quantum angular momentum and Clebsch–Gordan coefficients, and permutation groups for many-identical-particle systems with spin. The Lorentz group for special relativity and the Dirac equation for the relativistic electron, and perturbation theory and selection rules are also discussed. (J.F.P.)

**15612** COLEMAN'S THEOREM FOR SCALE INVARIANCE. Genz, H. (Univ. of California, Berkeley). Phys. Lett.; 31B: 146-7(2 Feb 1970).

If the dilatation charge annihilates the vacuum presence of zero mass states (or complete scale invariance) follows. (auth)

**15613** CP VIOLATION AND COSMOLOGICAL FIELDS. Nachtmann, O. (CERN, Geneva). Acta Phys. Austr.; Suppl. 6, 485-500(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The question of what information can be obtained on CP violation from existing experiments on cosmological fields is explored in a simple field theoretic model. (L.B.S.)

**15614** ON THE STRUCTURE OF PHENOMENOLOGICAL $SU_2 \times SU_2$ LAGRANGIANS. Banyai, L.; Novacu, B.; Rittenberg, V. (Inst. of Physics, Bucharest). Rev. Roum. Phys.; 14: 641-50(1969).

Applying the Coleman, Wess and Zumino theorems to the case of the $SU_2 \times SU_2$ group, a unified treatment of the chiral symmetric Lagrangians in the presence of gauge fields is given. For completeness, the symmetry breaking terms, considered as $SU_2 \times SU_2$ tensors, are also presented. (auth)

**15615** SEMISIMPLE SUBGROUPS OF SEMISIMPLE GROUPS. Stone, Anthony P. (St. Stephen's Coll., Delhi). J. Math. Phys. (N. Y.); 11: 29-38(Jan 1970).

The projection theorem for weights of a representation of a semisimple group G on restriction to a semisimple subgroup is derived, and the existence of a subgroup corresponding to a given projection is discussed. Dynkin's definition of the index of a simple subgroup is extended to the case of G being only semisimple, and the geometrical meaning of the index is given. A method is developed for finding branching rules for both regular and nonregular subgroups. Explicit general formulas for the branching multiplicities are obtained for all cases when G is of rank 2 and for $B_2(R_7) \rightarrow G_2$. Applications to the construction of weight diagrams and the "state-labeling" problems for $B_2$ and $G_2$ are mentioned. (auth)

**15616** PARITY AND TIME-REVERSAL INVARIANCE IN NUCLEAR PHYSICS. Henley, Ernest M. (Univ. of Washington, Seattle). Ann. Rev. Nucl. Sci.; 19: 367-432(1969).

The review of parity and time reversal in nuclear physics covers the basic theory of parity and time reversal invariance, consequences of P and T invariance in nuclear physics, theory of the parity-violating nuclear force, and theory for T-odd nuclear states. Also included are a classification of P and T experiments, parity experiments, present status of P violation and proposed experiments, time reversal experiments, the present status of T-violating searches, and searches for simultaneous violation of P and T invariances. (166 references) (J.F.P.)

**15617** TRANSLATION INVARIANCE OF LOCAL INTERNAL SYMMETRIES. Landau, Lawrence J.; Wichmann, Eyvind H. (Univ. of California, Berkeley). J. Math. Phys. (N. Y.); 11: 306-11(Jan 1970).

The notion of a local internal symmetry is discussed with reference to local physical theories and tentative definitions are presented. It is shown that under fairly general assumptions commonly made about local theories a local internal symmetry commutes with all translations. (auth)

**15618** GENERALIZED YOUNG TABLEAUX AND THE GENERAL LINEAR GROUP. King, R. C. (Univ. of Southampton, Eng.). J. Math. Phys. (N. Y.); 11: 280-93(Jan 1970).

A generalization of the Young tableau is defined, and use is made of this in the study of some of the properties of the irreducible representations (IR's) of each of the linear groups in n dimensions induced in a space defined by mixed tensors without recourse to lowering or raising of indices. A formula for the dimensions of any IR of $L_n$ is given. Procedures are derived for the reduction of the outer product of such IR's and for the decomposition of these IR's into IR's of some subgroups of interest in the theory of elementary particles. (auth)

**15619** BASES FOR IRREDUCIBLE REPRESENTATIONS OF THE UNITARY GROUP IN THE SYMPLECTIC GROUP CHAIN. Devi, V. Syamala (Andhra Univ., Waltair, India). J. Math. Phys. (N. Y.); 11: 162-8(Jan 1970).

A method of obtaining the highest weight polynomials of irreducible representations $(\lambda)$ of $Sp_{2n}$ occurring in a reduction of an irreducible representation $(k)$ of $U_{2n}$ is described. The highest-weight polynomials of equivalent representations $(\lambda)$ are labeled by means of parameters which occur naturally from the Littlewood's theorem to determine the branching rules for the representations of the unitary group with respect to the symplectic subgroup, when supplemented by modification rules. The results are given explicitly for $U_4 \supset Sp_4$ and $U_6 \supset Sp_6$, the former being a canonical chain and the latter a noncanonical chain. (auth)

**15620** BASES FOR IRREDUCIBLE REPRESENTATIONS OF $U_{2n}$ IN THE CHAIN $U_{2n} \supset U_n \dotplus U_n$. Devi, V. Syamala; Venkatarayudu, T. (Andhra Univ., Waltair, India). J. Math. Phys. (N. Y.); 11: 169-73(Jan 1970).

The highest weight polynomials of irreducible representations of a $U_3 \times U_3$ subgroup of $U_6$, which occur in the reduction of a given irreducible representation of $U_6$, are obtained, making use of Littlewood's rules for the reduction of an irreducible representation of $U_6$ with respect to a $U_3 \times U_3$ subgroup. The various irreducible representations of $U_3 \times U_3$ occurring in the reduction are uniquely labeled by parameters which are obtained in a natural and obvious way from Littlewood diagrams. These polynomials could not be obtained by the algebraic methods developed so far. The method described here overcomes the division problem encountered there and makes the solution possible. It can also be directly extended to the case of $U_{2n} \supset U_n \dotplus U_n$ for any n. (auth)

**15621** MODELS OF LOCAL CURRENT ALGEBRA AND SYMMETRY BREAKING. Ghielmetti, Francesco (Univ., Bern). Helv. Phys. Acta; 43: 67-73(16 Feb 1970).

It is shown that a known model of local current algebra in the infinite momentum limit can be generalized to a model which includes symmetry breaking solutions. The model can further be extended to allow transitions between states of different total isospin value. The methods of generalization apply to higher algebras as well as to the $SU_3$-model. (auth)

**15622** LECTURES ON LIE GROUPS. Adams, J. Frank. Mathematics Lecture Note Series. New York; W. A. Benjamin, Inc. (1969). 192p.

A basic syllabus of Lie groups is concisely presented with proofs. The basic definitions, one-parameter subgroups, the exponential map, elementary representation theory, maximal tori in Lie groups, geometry of the Stiefel diagram, representation theory, and representations of the classical groups are covered. (J.F.P.)

**15623** ABOUT THE SO(3,2) GROUP AS GROUP OF SPACE–TIME SYMMETRY. Le Maire, Patrick (Institut Henri Poincare, Paris). Compt. Rend., Ser. A; 270: 80-1(5 Jan 1970). (In French).

Two theorems concerning the contraction of G groups to group P (inhomogeneous Lorentz group) and two theorems concerning the representations of these groups transformed into physical representations of P are given. (France)

**15624** GEOMETRY OF CHIRAL DYNAMICS. I. Dowker, J. S. (Univ. of Manchester, Eng.). J. Phys. A (London); 3: 33-44(Jan 1970).

The group-theoretical discussion of chiral dynamics is re-expressed in analytical terms appropriate to the geometry of group space. Closed, but transcendental, expressions are given for the meson Lagrangian for the cases of $G \otimes G$ in general and $SU(2) \otimes SU(2)$ in particular. (auth) (UK)

**15625** GEOMETRY OF CHIRAL DYNAMICS. II. Dowker, J. S. (Univ. of Manchester, Eng.). J. Phys., A (London); 3: 45-58(Jan 1970).

Previous work on the geometry of group space appropriate to the problem of chiral symmetry is extended to cover "other fields" with the object of elucidating the relation between those fields which transform linearly and those which do not. The different fields just correspond to different choices of the local coordinates which must be set up to define "spinors." The results for specific quantities such as transformation matrices and covariant derivatives agree with those of other papers. (auth) (UK)

### Applications (Electromagnetic and Weak)

*Refer also to abstracts 15533, 15649, and 15861.*

15626 (INP-681, pp 46-58) CP VIOLATION AND PARTICLE MIXTURE MODELS. Ryndin, R. M. (Joint Inst. for Nuclear Research, Dubna (USSR)).

The main features of CP conserving models are reviewed, and some experiments for the two-pion decay mode of the neutral kaon which are tests of such models are discussed. It is found that any quantum mechanical description of present experimental data is not possible. (J.F.P.)

15627 AN UNDERGROUND EXPERIMENT ON NEUTRINO-LESS DOUBLE BETA-DECAY. Fiorini, E. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan); Pullia, A.; Bertolini, G.; Cappellani, F.; Restelli, G. Lett. Nuovo Cim.; 3: 149-52 (29 Jan 1970).

The results of an underground experiment on the decay $^{76}Ge \rightarrow {}^{76}Se + 2e^-$ are presented. A Ge(Li) crystal is used as a source and a detector for the decay. The spectrum is shown, and a limit for the rate of this decay is determined. An upper limit is given for the lepton nonconservation parameter determined from this decay. (J.F.P.)

15628 EXPERIMENTAL TESTS OF CPT, CP, C, AND T INVARIANCES. Conforto, G. (Univ. of Chicago). Acta Phys. Austr.; Suppl. 6, 435-53(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

Some recent results of experimental tests of CPT, CP, C, and T invariances are discussed. It is concluded that no direct and convincing evidence for T violation exists and that the breakdown of CP invariance is still confined to neutral K meson phenomena. (L.B.S.)

### Applications (Strong)

*Refer also to abstracts 15575, 15639, and 15667.*

15629 (INP-681, pp 29-45) A NONLINEAR REALIZATION AND BREAKING OF SU(3)-SYMMETRY. Ogievetskii, V. (Joint Inst. for Nuclear Research, Dubna (USSR)).

It is shown that the nonlinear method is very convenient for the treatment of symmetry breaking. The simplest nonlinear realization of SU(3) is analogous to that of SU(2) × SU(2). All features of nonlinear realizations are easily seen, and a generalization to SU(3) × SU(3) is evident. Also the problem of the derivation of mass formulas with the additional requirement of a reasonably high-energy behavior of scattering amplitudes is discussed. (J.F.P.)

15630 GEOMETRY IN INTRINSIC SPACE OF STRONGLY INTERACTING PARTICLES. Alderman, Jerry Lee. (Washington, D. C.; George Washington Univ. (1969). 106p.
Thesis.

A completely geometrical treatment is given of the idea proposed by C. N. Yang and R. L. Mills that the concept of locality in field theory requires that a theory which is invariant under the transformations of an intrinsic symmetry group C should remain invariant when the transformations of G are allowed to depend upon the space–time coordinates $x^n$. The appellation "intrinsic" is used simply to distinguish symmetry groups which do not involve transformations of the space–time coordinates from those such as the Lorentz group which do. An "intrinsic space" is then simply a representation space for some representation of an intrinsic symmetry group G. The group SU3 is used as an example of an intrinsic symmetry group throughout. (Diss. Abstr.)

15631 S-WAVE BOUND STATES IMPLIED BY THE SU(3) x SU(3) CHARGE ALGEBRA. Von Hippel, F.; Finkelstein, J. (Stanford Univ., Calif.). Phys. Lett.; 31B: 226-9(16 Feb 1970).

It is shown within the framework of a previously tested approximation scheme that the existence of certain s-wave bound states is implied by the SU(3) × SU(3) charge algebra in the SU(3) symmetry limit. These states correspond to the $\frac{1}{2}^-$ SU(3) singlet and octet, and to a single meson with $J^{PC} = 1^{+-}$ below 1265 MeV. Two $1^+$ octets corresponding to the $A_1$ and B octets are found to be bound or almost bound. (auth)

15632 EXPLICIT REPRESENTATIONS OF CHIRAL INVARIANT LAGRANGIAN THEORIES OF HADRON DYNAMICS. MacFarlane, A. J.; Sudbery, A.; Weisz, P. (Univ. of Cambridge, Eng.). Proc. Roy. Soc. (London), Ser. B; 314: 217-50(6 Jan 1970).

The general algebraic properties of and relations between the SU(n) tensors which characterize a Lagrangian theory invariant under chiral SU(n) × SU(n) are studied. These tensors are the tensors $F_{ij}$ and $v_{ij}$ which specify the chiral transformation laws of $0^-$ meson and other multiplets of fields, together with SU(n) tensors which allow covariant derivatives of such fields to be built. Knowledge of these tensors is necessary and sufficient for the construction of SU(n) × SU(n) invariant Lagrangians and the related vector and axial vector currents. The results include a vital, previously unnoticed, constraint on allowed $F_{ij}$ and completely new, and surprisingly simple, formulas for $v_{ij}$ and the other relevant SU(n) tensors. The general results for n = 3 are applied, giving explicit forms of possible $F_{ij}$ and proceeding thence to the creation of two simple models, the Cube Root and Rational Models of chiral SU(3) × SU(3), in which can be written down explicit closed forms for all SU(3) tensors required for physical application. These models are quite new. The work goes beyond that of Coleman, Wess and Zumino (1968) in that its general discussion is aimed towards and its SU(3) part actually achieves the writing down of all results in closed form rather than giving only the early terms of power series expansions. It is possible to include explicitly and in closed form in each of our SU(3) models terms which give rise to symmetry breaking according to the scheme of Gell-Mann, Oakes and Renner (1968). (auth) (UK)

## Field Theories

### General

15633 COSMOLOGICAL UNIVERSE MODEL OF PROJECTIVE FIELD THEORY. Macheleidt, Gerd (Theoretisch-Physikalisches Institut, Jena, Ger.). Wiss. Z. Friedrich-Schiller-Univ., Jena, Math.-Naturwiss. Reihe; 17: 219-21(1968). (In German).

Five-dimensional projective relativity theory can be formulated four-dimensionally as a unitary theory of gravitation and electromagnetism if a scalar field is added. Field equations can be drawn from the four-dimensional variation principle in the Maxwell field free case. The cosmological differential equation is compared with the extremely complicated equation of Jordan; it is independent of the state of the material chosen as the ideal medium. The Friedman equation in Einstein cosmology used in connection with the integrability condition is expanded through the scalar field. Consequences of the theory are drawn. The Jordan hypothesis of material production is not combinable with the variants of projective theory considered here; the development of organic life in spite of more intense radiation from the sun can thus be understood in terms of a greater gravitation number at that time. The spherically symmetric vacuum solution must be nonstatic. (BBB).

15634 DISSIPATIVITY AND LIE-ADMISSIBLE ALGEBRAS. Santilli, Ruggero M. (Boston Univ.). Meccanica; 4: No. 1, 3-11(Mar 1969).

The validity of Hamiltonian mechanics and Lie algebra invariance for free fields and their difficulties for interacting fields are recalled. The role of dissipativity is discussed as an approach allowing the introduction for interacting regions of larger analytical dynamics and algebraic formulations related by the enlarged bracket. A working criterion is introduced in terms of Lie-admissible algebras and the pseudo-Hamiltonian mechanics introduced previously for discrete dissipative systems is considered as an explicit choice able to reduce to the Hamiltonian mechanics when the systems become conservative. An example of dissipative plasma is explicitly investigated. Furthermore the procedure is extended to continuous systems and classical interpolating dissipative fields induced by Lie-admissible structures are constructed. (auth)

### Quantum Field Theory

*Refer also to abstracts 15429, 15440, 15501, 15554, 15611, 15614, 15632, and 15677.*

15635 (INP-681, pp 6-28) PHYSICAL SYMMETRIES IN THE FRAMEWORK OF QUANTUM FIELD THEORY. Lopuszanski, Jan T. (Wroclaw Univ. (Poland). Inst. of Theoretical Physics).

The general problem of exploring physical symmetries in a theory of several scalar real fields subjected to some fairly weak restrictions is discussed. Restriction is made to physical symmetries which commute with the Poincaré group and with the CPT operator. It is concluded that to every admissible n-dimensional representation of SU(3) there corresponds a pair–conjugate multiplet of n complex fermion fields. (J.F.P.)

**15636** (INP-681, pp 126-49) QUANTUM MARKOVIAN PROCESSES IN THE QUANTUM MECHANICS. Garczynski, W. (Wroclaw Univ. (Poland). Inst. of Theoretical Physics).

A short introduction is given of a theory of the simplest possible quantum Markovian process with a continuous set of states and continuous time which corresponds to the one-particle quantum system. This theory provides very natural language for the whole quantum theory including relativistic quantum field theory. The most general Schroedinger equations describing the particle moving under the presence of an external electromagnetic field are derived. (J.F.P.)

**15637** (JINR-E2-4832) PHYSICAL SYMMETRIES IN THE FRAMEWORK OF QUANTUM FIELD THEORY. II. Lopuszanski, Jan T. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1969. 18p. Dep. CFSTI (U. S. Sales Only).

It is proved that the original free fields and those obtained under the symmetry representation are linked together by a linear representation (nonlocal, in general). Many physicists conjectured these relations to be linear, although no proof was given so far. (auth)

**15638** (NYO-3829-43) EXACTLY SOLUBLE MODEL OF RELATIVISTIC FIELD THEORY. Bialynicki-Birula, I. (Pittsburgh Univ., Pa. Dept. of Physics). Dec 1969. Contract AT-(30-1)-3829. 10p. Dep. CFSTI.

An exactly soluble model of relativistically invariant and local quantum field theory is described. It satisfies all the usual postulates except the requirement of the positive definiteness of either the energy or the metric in the space of state vectors. The S operator is nontrivial and is explicitly given. The two-particle scattering amplitude is calculated. Various generalizations of the model are possible. (auth)

**15639** $\omega-\phi$ MASS-MIXING MODEL, EQUAL-TIME COMMUTATION RELATIONS OF SUGAWARA AND SYMMETRY BREAKING ALGEBRA OF FIELDS. Cremmer, E. (Faculte des Sciences, Orsay, France). Nucl. Phys.; B15: 131-45(1970).

It is shown that equal-time commutators of currents of Sugawara are consistent with $\omega-\phi$ mass-mixing model, a natural mixing is introduced between space components of the singlet and the 8th current. All the results are rederived from a Lagrangian of Yang-Mills fields with symmetry breaking mass terms. (auth)

**15640** PARTICLES THAT GO FASTER THAN LIGHT. Feinberg, Gerald. Sci. Amer.; 222: No. 2, 69-73; 76-7(Feb 1970).

Properties of tachyons, particles with an imaginary rest mass and constrained to travel faster than the speed of light, which are consistent with the special theory of relativity, are discussed. Experimental attempts to produce and detect tachyons are also described. (C.E.S.)

**15641** INTRODUCTION TO QUANTUM FIELD THEORY. Roman, Paul. New York; John Wiley and Sons, Inc. (1969). 646p. $18.00.

The treatment of quantum field theory is divided into two parts. Part 1 deals with Lagrangian field theory, including Feynman graph techniques and perturbation theory. Part 2 is concerned with more advanced and modern topics, such as the various axiomatic approaches to the theory, general properties of collision amplitudes, and the fundamentals of dynamical calculations in hadron physics. (L.B.S.)

**15642** DUAL SELF-ENERGY DIAGRAM IN THE OPERATORIAL FORMALISM. Guerin, F. (Physique Theorique, Nice). Lett. Nuovo Cim.; 2: 895-903(21 Dec 1969).

An operational formalism was previously obtained which allows simple dual diagrams to be written as factorized products of propagators and vertex functions. The question of whether, in this operational formalism, the knowledge of the vertex and of its propagator is enough to calculate general planar diagrams is considered. The operational formalism relates resonances to eigenstates of harmonic oscillators. A self-energy diagram is calculated and compared with the one-loop dual amplitude. It is concluded that, in this operational formalism, the four-resonance function is needed before any general planar diagram can be calculated. (L.B.S.)

**15643** METHOD TO CALCULATE DOUBLE LOGARITHMIC ASYMPTOTICS. Terent'ev, M. V. (Kiev State Univ.). Yadern. Fiz.; 10: 1253-61(1969). (In Russian).

Prescription is given for calculation of the double logarithmic asymptotics for annihilation processes. The prescription is based on the use of properties of the bremsstrahlung in the quantum electrodynamics at high energies and with the account of an equation for the derivative of the amplitude on $e^2$. (auth)

**15644** ON FIELD THEORY IN THE FRIEDMAN SPACE. Grib, A. A.; Mamaev, S. G. (Leningrad State Univ.). Yadern. Fiz.; 10: 1276-81(1969). (In Russian).

Quantization of a scalar field in the Friedman quasi-euclidean space is considered. The fact that the metrics is not stationary results in the necessity to consider the non-Fock representations of the time-dependent commutation relations. The representation is determined by the requirement on the Hamiltonian to be diagonal that corresponds to a Bogolubov transformation of the creation and annihilation operators. Estimates are obtained for the arising "anomalous" mean values as well as for the classical particle number density in the vacuum state. (auth)

**15645** TOTAL SET OF FUNCTIONS ON THE UNPARTED HYPERBOLOID. Verdiev, I. A. (Inst. of Physics, Baku). Yadern. Fiz.; 10: 1282-6(1969). (In Russian).

Total set of functions to expand any function field determined on the unparted hyperboloid is obtained. (auth)

**15646** LINEAR COMBINATIONS OF RADIATIVE CORRECTIONS: RENORMALIZATION GROUP AND RENORMALIZATION THEORY. Visconti, A. (Univ. of Aix, Marseille). Nuovo Cim.; 65A: 617-36(21 Feb 1970).

General renormalization transformations defined as linear combinations of radiative corrections and of their derivatives with respect to the squared mass are considered. It is then shown that the transformations belonging to the conventional renormalization group are particular cases of these general transformations. Conditions under which such general renormalization transformations build up a group are studied, its representations are characterized and finally the connection between these transformations and the renormalization theory are investigated. (auth)

**15647** FIELD AND PARTICLE EQUATIONS FOR THE CLASSICAL YANG-MILLS FIELD AND PARTICLES WITH ISOTOPIC SPIN. Wong, S. K. (State Univ. of New York, Stony Brook). Nuovo Cim.; 65A: 689-94(21 Feb 1970).

A complete system of equations describing the interaction between the Yang-Mills field and isotopic-spin-carrying particles in the classical limit is extracted from the equations of motion for the quantum fields. Some simple consequences are derived. The consistency of the equations is investigated. (auth)

**15648** MASS, CHARGE, AND WAVE FUNCTION RENORMALIZATION IN THE THEORY WITH PARITY NONCONSERVATION. Vasilev, A. N.; Kitanin, A. L. (Leningrad State Univ.). Zh. Eksp. Teor. Fiz.; 57: 1629-34(Nov 1969). (In Russian).

The quantum electrodynamics renormalization procedure is extended to parity nonconservation theory of the type of weak lepton or quark interaction with an intermediate boson. Since such theories are nonrenormalizable the calculations are performed on the assumption that cut-off is introduced into the theory. The latter differs from quantum electrodynamics in the appearance of pseudoscalars in the fermion propagators and in the possibility of particle mixing (for example weak quark interaction may produce a direct transition of a n-quark into a $\Lambda$-quark). Renormalization of the wave function in such a theory requires the introduction of a matrix relating the renormalized and nonrenormalized fields. Renormalization is not expressed in terms of counter-terms introduced into the initial Lagrangian but rather in terms of skeleton graphs. (auth)

**15649** EFFECTIVE LAGRANGIANS AND SU(3) x SU(3) SYMMETRY BREAKING. Gasiorowicz, S. (Univ. of Minnesota, Minneapolis. Deutsches Elektronen Synchrotron, Hamburg). Acta Phys. Austr.; Suppl. 6, 19-51(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The effective Lagrangian technique is applied to the study of chiral SU(3) × SU(3). As a background to a detailed discussion of a model Lagrangian, the Lagrangian formalism is reviewed, and the transformation properties of fields are discussed. It is shown how field algebra and symmetry breaking that leads to PCAC are implemented. In the discussion of the model, emphasis is placed on the leptonic decay constants of the spin-0 and spin-1 mesons for comparison with experiment. The technical aspects of constructing effective Lagrangians are considered in detail. (L.B.S.)

**15650** HAMILTONIAN APPROACH TO QUANTUM FIELD THEORY. Klauder, John R. (Bell Telephone Labs., Inc., Murray Hill, N. J.). Acta Phys. Austr.; Suppl. 6, 167-214(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

Some general features of a Hamiltonian quantum field theory along with some results regarding existence questions for certain model field theories are discussed. (L.B.S.)

**15651** STOCHASTIC APPROACH TO QUANTUM MECHANICS AND TO QUANTUM FIELD THEORY. Garczynski, W. (Univ. of Wroclaw). Acta Phys. Austr.; Suppl. 6, 501-17(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The on-mass-shell formulation of S-matrix theory is first discussed and the causality postulate is given in terms of physical amplitudes. The corresponding off-mass-shell formulation is then treated and the Bogolyubov causality postulate used in a functional formulation of quantum field theory is derived. The stochastic approach to the conventional formulation of the quantum theory of fields is discussed. (L.B.S.)

**15652** EXTENSION OF THE CONVENTIONAL FRAMEWORK OF LOCAL QUANTUM FIELD THEORY AND THE DESCRIPTION OF RESONANCES. Lukierski, Jerzy (Univ. of Wroclaw). Acta Phys. Austr.; Suppl. 6, 518-35(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

It is shown that the field operator $\phi(x,s)$, with continuous spectrum of asymptotic mass, can be used in the construction of self-contained quantum field theory with unstable elementary objects. Spin-zero stable particles and the unstable elementary objects representing S-wave two-particle resonances are considered. The results can be generalized to the case of a physical system of interacting stable particles with spin and arbitrary multiparticle resonances. Two examples are discussed: the bilinear interaction model, and the decay vertex of the Yukawa type. (L.B.S.)

**15653** NONLINEAR SPINOR THEORY IN DE SITTER SPACE. Boerner, G.; Duerr, H. P. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Nuovo Cim.; 66A: 185-201(1 Mar 1970).

The nonlinear spinor equation is formulated in a de Sitter space with symmetry group $SO_{1,4}$. The curvature of space-time introduces an absolute scale of length R which leads to a breakdown of dilatation invariance. If this radius R is postulated to be the only scale of length in the theory, noncanonical quantization seems unavoidable. In particular, a quantization procedure is discussed, which introduces the fundamental length R into the theory, even at very small space-time distances, near the light cone. As a further point the definition of a parity operation in nonlinear spinor theory is suggested, using the discrete transformation connecting antipodal points in de Sitter space. (auth)

**15654** ABSENCE OF ABNORMAL COMMUTATION RELATIONS BETWEEN DIFFERENT COMPONENTS OF A FIELD. Roepstorff, G. (Univ., Hamburg). Nuovo Cim.; 66A: 104-10(1 Mar 1970).

Some properties of multicomponent fields related to locality and Carruthers' theorem are derived. (auth)

**15655** $O_5$ CLASSIFICATION OF BETHE–SALPETER SOLUTIONS. Breitenlohner, P.; zur Linden, E. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Nuovo Cim.; 66A: 47-56(1 Mar 1970).

The solutions of the ladder approximation of the scalar Bethe-Salpeter equation are investigated with regard to their dependence on the mass $\mu$ of the exchanged particle. It is found that: 1) The $O_5$ degeneracy exhibited by the eigenvalue spectrum in the case $\mu = s = 0$ is not completely destroyed even for very large $\mu$. The existence of one infinite series of Lorentz poles follows. 2) The Toller $O_4$ invariance of the equation occurs in the limit $\mu \to \infty$ for arbitrary finite s. The connection of the limiting case $\mu \to \infty$ with the Zachariasen model is investigated. (auth)

**15656** GLOBAL SOLUTIONS IN SOME RENORMALIZATION GROUPS. Astaud, M. (College de France, Paris). Nuovo Cim.; 66A: 111-28(1 Mar 1970).

The solutions invertible and differentiable with respect to the energy variable of functional equations in some renormalization "groups" were introduced in a preceding paper $G^{s}_{s=0}(Z_3)$, $G^{s^2}_{s^2=0}(Z_3 Z_1^{-1} Z_1^{-2})$, $G^{s^2}(Z_3,\mu)$, $G_{\mu^2/m^2,\, s^2}(\mu)$. The paradoxical result obtained by Gell-Mann and Low, in $G_{\mu m}(Z_3)$, is explained and resolved according to which the bare electron charge does not depend on the observable one. (auth)

**15657** FIELDS, OBSERVABLES, AND GAUGE TRANSFORMATIONS. II. Doplicher, Sergio (Faculte des Sciences, Marseille); Haag, Rudolf; Roberts, John E. Commun. Math. Phys.; 15: 173-200(23 Dec 1969).

The construction of charge-carrying fields are studied given the representation of the observable algebra in the sector of states of zero charge. It is shown that the set of those covariant sectors which can be obtained from the vacuum sector by acting with "localized automorphisms" has the structure of a discrete Abelian group G. An algebra of fields F can be defined on the Hilbert space of a representation $\pi$ of the observable algebra U which contains each of the above sectors exactly once. The dual group of G acts as a gauge group on F in such a way that $\pi(U)$ is the gauge invariant part of F. F is made up of Bose and Fermi fields and is determined uniquely by the commutation relations between spacelike separated fields. (auth)

**15658** CONVERGENCE OF BOGOLYUBOV'S METHOD OF RENORMALIZATION IN MOMENTUM SPACE. Zimmermann, W. (Institut des Hautes Etudes Scientifiques, Bures-sur-Yvette, France. Istituto di Fisica Teorica, Naples). Commun. Math. Phys.; 15: 208-34(23 Dec 1969).

Bogoliubov's method of renormalization is formulated in momentum space. The convergence of the renormalized Feynman integrand is proved by an application of the power-counting theorem. (auth)

**15659** MATHEMATICAL DISCUSSION OF THE PAULI AND FIERZ MODEL RELATIVE TO THE INFRARED CATASTROPHE. Blanchard, Philippe (Eidgenoessische Technische Hochschule, Zurich). Commun. Math. Phys.; 15: 156-72(12 Dec 1969). (In French).

In this model the interaction of a quantized nonrelativistic electron with the photon field is studied. The system is discussed for all finite time and one is in the position to construct explicitly the asymptotic states. (auth)

**15660** SINE-GORDON EQUATION. Rubinstein, Julio (Univ. of Saskatchewan, Saskatoon). J. Math. Phys. (N. Y.); 11: 258-66(Jan 1970).

The equation $\phi_{tt} - \phi_{xx} + m^2 \sin \phi = 0$ is presented as a model field theory and studied in detail. It exhibits discrete conserved quantities and extended particle states, with the proper behavior regarding covariance, stability, etc. Those particles do not interact with small oscillations, and it is shown that this (plus a few reasonable requirements) defines the model uniquely. A connection with the Korteweg-de Vries equation, which has similar properties, is established. (auth)

**15661** RENORMALIZED PERTURBATION THEORY FOR THE WEAKLY NONLINEAR OSCILLATOR. Aks, S. Oe.; Carhart, R. A. (Univ. of Illinois, Chicago). J. Math. Phys. (N. Y.); 11: 214-22(Jan 1970).

The problem of finding solutions for the weakly nonlinear quantum oscillator is investigated in the Heisenberg representation in one dimension. The perturbation method developed makes allowance for the nonisochronous nature of nonlinear oscillations and avoids at any level of approximation the secularity—terms increasing without bound as $t \to \infty$—intrinsic to the usual type of iteration scheme. The treatment of the general quantum equation $(d^2/dt^2 + \omega^2)x(t) = \epsilon f(x)$, for the Heisenberg position operator x(t), is first motivated by the classical analog. The iteration equations for the quantum case are derived, and the case $f(x) = x^3$ is studied fully to order $\epsilon$, and partially to order $\epsilon^2$. (auth)

**15662** DEGENERACY OF THE DIRAC EQUATION WITH ELECTRIC AND MAGNETIC COULOMB POTENTIALS. Berrondo, Manuel; McIntosh, Harold V. (Uppsala Univ.). J. Math. Phys. (N. Y.); 11: 125-41(Jan 1970).

Investigation is made of the symmetry and degeneracy of the Dirac equation for a Coulomb potential with a fixed center bearing both electric and magnetic charge. Seen from the viewpoint of classical mechanics, relativistic precession removes the accidental degeneracy of the nonrelativistic potential, and may be so severe as to lead to spiral rather than precessing elliptic orbits. The degeneracy may be restored by the introduction of a vector potential which combats the precession and leads to closed relativistic orbits. An angular momentum and a Runge vector are found for the "symmetric" potential for arbitrary values of electric and magnetic nuclear charges. A related symmetric Hamiltonian and constants of the motion may be constructed for the Dirac equation, which reduce to those of Biedenharn and Swamy in the absence of magnetic charge. Magnetic charge must be quantized—a requirement seen from the angular part of the wave function exactly as in the nonrelativistic problem. The Dirac Hamiltonian is singular for the lowest admissible angular momentum state, corresponding to the spiral orbits, when the magnetic charge is nonzero. The remaining states show an accidental doubling of degeneracy, whose presence may be deduced from an operator which reduces to that of Johnson and Lippman, or the algebra of Malkin and Manko, without the magnetic charge. (auth)

**15663** EXISTENCE AND UNIQUENESS OF CROSSING SYMMETRIC N/D-TYPE EQUATIONS CORRESPONDING TO THE KLEIN–GORDON EQUATION. Cornille, H. (CEN de Saclay, Gif-sur-Yvette, France). J. Math. Phys. (N. Y.); 11: 79-98(Jan 1970).

N/D-type equations satisfying crossing symmetry are established inside the relativistic wave-mechanics formalism (Klein-Gordon equations). It is shown that, for a superposition of exponential potentials with finite zeroth moment, the N/D-type

equations have unique solutions. Furthermore, for sufficiently weak couplings the solutions are physically available. (auth)

**15664** ASYMPTOTIC FIELDS IN SOME MODELS OF QUANTUM FIELD THEORY. III. Hoegh-Krohn, Raphael (Univ. of Oslo). J. Math. Phys. (N. Y.); 11: 185-8(Jan 1970).

The model of a relativistic boson field, interacting in a local way with a nonrelativistic nucleon field is considered. This model was studied by Nelson, who proved that after an infinite nucleon self-energy renormalization, the total energy becomes a self-adjoint operator. It is proved that the asymptotic limits of the boson field exist. (auth)

**15665** FIELD-THEORETIC DESCRIPTION OF MASSLESS PARTICLES WITH HIGHER SPIN AND DEFINITE PARITY. I. INTEGER SPIN. Cukierda, T.; Lukierski, J. (Univ. of Wroclaw). J. Math. Phys. (N. Y.); 11: 46-50(Jan 1970).

It is known that there exist S + 1 equivalent covariant formulations of the theory of free massive particles with integer spin S and definite parity P. From these S + 1 equivalent theories one gets by putting m = 0 the description of S + 1 different massless particles, with helicities (k, −k), k = 0, 1, ⋯, S. This property is already known in the case S = 1. It is demonstrated explicitly how to obtain three kinds of massless particles, with different helicities, from three equivalent formulations of free massive theory with S = 2. Further, the general argument is outlined for arbitrary integer value of S. (auth)

**15666** KERNEL INTEGRAL FORMULAS FOR THE CANONICAL COMMUTATION RELATIONS OF QUANTUM FIELDS. II. IRREDUCIBLE REPRESENTATIONS. Hegerfeldt, Gerhard C. (Univ., Marburg, Ger.). J. Math. Phys. (N. Y.); 11: 21-9(Jan 1970).

Continuing an investigation of the kernel or group integral for the canonical commutation relations introduced by Klauder and McKenna, it is proved that a representation fulfilling any sort of kernel integral formula is irreducible. This has been conjectured by Klauder and McKenna. After collecting some auxiliary results, a complete classification of all representations is given for which a kernel integral formula in the form of a limit superior holds. It is shown that these are just the partial tensor-product representations and that the limit superior can be replaced by an ordinary limit over a fixed subsequence, thus allowing the transition from norms to scalar products. Then the basis-independent kernel integral in the form of a sup $\overline{\lim}$ is investigated. Here the supremum is taken over all bases of the test-function space. Under a not-very-strong irreducibility assumption, it is shown that this can be reduced to the vacuum functional and that there exists a fixed sequence of subspaces of the test-function space such that the sup $\overline{\lim}$ can be replaced by an ordinary limit which again allows a transition to scalar products. The results are strikingly similar to the case of cyclic field. This leads us to the conjecture that a representation fulfilling a kernel integral formula is both irreducible and cyclic with respect to the field just as in the case of finitely many degrees of freedom. (auth)

**15667** NON-LOCAL YANG–MILLS THEORY. Dowker, J. S. (Univ. of Manchester, Eng.). J. Phys. A (London); 3: 59-69(Jan 1970).

The Yang–Mills theory assumes that the parameters of the internal SU(2) group are functions of space–time. This is generalized by making the parameters matrices in space–time. When these are diagonal the original theory is recovered. Instead of transforming according to just the regular representation, it is found that the gauge field contains all representations consistent with angular momentum conservation. A further novelty is a metric introduced to make bilinears invariant and similarities to chiral invariance are pointed out. A suggested physical motivation is the existence of the Planck length. (auth) (UK)

## *Gravitation and General Relativity*

*Refer also to abstract 15613.*

**15668** (N-70-12098) SYSTEMS OF SELF-GRAVITATING PARTICLES IN GENERAL RELATIVITY. Ruffini, Remo; Bonazzola, Silvano (Institute for Advanced Study, Princeton, N. J.). [1968]. 68p. (NASA-CR-107073). CFSTI.

A method of self-consistent fields is used to study the equilibrium configurations of a system of self-gravitating scalar bosons or spin ½ fermions in the ground state without using the traditional perfect fluid approximation or equation of state. A nonrelativistic Newtonian approximation is developed and the corrections due to special and general relativity explicitly pointed out. Both fermions and bosons, in the Newtonian nonrelativistic approximation, a solution exists for any number of particles and the solutions differ only by a scale factor. A critical mass of gravitational collapse is found for a system of N × (Planck mass/m) sq self-gravitating bosons in the ground state. It is shown that there exists an interaction between gravitational and spinor field but its magnitude is generally negligible. The problem of an elementary scalar particle held together only by its gravitational field is meaningless in this context. (auth) (STAR)

**15669** LINEAR THEORY OF GRAVITATION. Bollini, C. G. (Univ. Nacional, La Plata); Giambiagi, J. J.; Tiomno, J. Lett. Nuovo Cim.; 3: 65-70(15 Jan 1970).

A linear, nonlocal theory of gravitation was recently found by Deser and Laurent (Ann. of Phys., 50: 76(1968)), which leads to a tensor field for the static point particle, identical to the linearized Schwarzschild solution. An alternative theory is presented that leads to the same results. Both theories coincide when the energy-momentum tensor is conserved. (L.B.S.)

**15670** SPINORIAL VARIATIONAL PRINCIPLE FOR EINSTEIN GRAVITATIONAL FIELDS. Brinis, Elisa Udeschini. Atti Accad. Naz. Lincei, Rend., Cl. Sci. Fis., Mat. Natur.; 46: 249-60 (Mar 1969). (In Italian).

In a Riemannian space-time, when Einstein gravitational equations for empty space are satisfied, its curvatures are characterized by a totally symmetric four-index spinor: the gravitational spinor. Such a spinor satisfies equations which are similar to the spinor equations for a source-free electromagnetic field. Using this analogy, the field equations of the gravitational spinor are here derived from a variational principle. (auth)

**15671** GENERAL RELATIVITY THEORY AND THE NON-EUCLIDEAN GEOMETRY. Janossy, Lajos (Central Research Inst. for Physics, Budapest). Fiz. Szemle; 19: 321-7(Nov 1969). (In Hungarian).

From the additivity law of velocity, the reference systems needed for the determination of physical processes are examined. The path of a light signal may be determined by means of a symmetric matrix; a similar system may be used to determine whether the region in which particles propagate is truly homogeneous or not. The fact that the same symmetric matrix is involved in the identification of the paths of both light beams and particles indicates that it refers to a truly fundamental physical field, identifying the ether as the carrier of both matter and light waves. This principle appears either explicitly or implicitly in the laws derived from the law of general relativity. This theory does not contradict any of the observed phenomena and thus it may be assumed that it refers indeed to a field which affects all physical processes. (TTT)

**15672** ZAKLADY OBECNE TEORIE RELATIVITY. (Principles of General Theory of Relativity). Kuchar, Karel. Praha; Ceskoslovenska Akademie Ved (1968). 253p.

A historical introduction to the theory of relativity is followed by symbols and definitions. Noninertial systems with discussions of measurements related to the theory, allowable systems, and space-time measurements are considered. Principles of Riemannian geometry; principles of the theory of relativity in noninertial systems; the general theory of relativity; and determination of the Einstein gravitational laws and motion equations of experimental particles using linear approximations and equatorial-field and spherical-symmetry studies are discussed. (184 references). (TTT)

**15673** STABILITY OF GENERAL RELATIVISTIC GASEOUS MASSES AND VARIATIONAL PRINCIPLES. Taub, A. H. (Univ. of California, Berkeley). Contract AT(11-1)-34. Commun. Math. Phys.; 15: 235-54(23 Dec 1969).

The Einstein field equations for a self-gravitating fluid that obeys an equation of state of the form p = p(w), p the pressure and w the energy density, may be derived from a variational principle. The perturbations of the metric tensor and the fluid dynamic variables satisfy equations which may be derived from a related variational principle, namely the principle associated with the "second variation problem." It is shown that the variational principle given by Chandrasekhar from which a sufficient criterion may be obtained for deciding when a self-gravitating spherical gaseous mass is unstable against spherically symmetric perturbations is that given by the "second variation problem." It is further shown that this criterion is equivalent to requiring that the integral entering into the second variation be negative. The latter form of the criterion may be used in general situations. (auth)

**15674** NULL ELECTROMAGNETIC FIELDS IN GENERAL RELATIVITY ADMITTING TIMELIKE OR NULL KILLING VECTORS. Banerjee, A. (Jadavpur Univ., Calcutta). J. Math. Phys. (N. Y.); 11: 51-5(Jan 1970).

A study of stationary null electromagnetic fields coexisting with a dust distribution is presented. Two exact solutions correspond-

ing to pure radiation fields with the propagation vector as the Killing vector are presented. (auth)

**15675** SPINOR STRUCTURE OF SPACE-TIMES IN GENERAL RELATIVITY. II. Geroch, Robert (Birkbeck Coll., London). J. Math. Phys. (N. Y.); 11: 343-8(Jan 1970).

Spinor fields can only be defined on a space-time which has been given a spinor structure. A number of conditions (some sufficient, others necessary and sufficient) for the existence of a spinor structure are derived. By applying one or another of these conditions, it is shown that many well-known solutions of Einstein's equations do have spinor structure. The question of the existence of spinor structure depends only on the topology of the underlying manifold, not on the (time- and space-oriented) metric. It is shown that, nonetheless, a certain "threshold" of curvature must be exceeded before there can be even the possibility of a space-time's having no spinor structure. (auth)

**15676** DYNAMICS OF EXTENDED BODIES IN GENERAL RELATIVITY. I. MOMENTUM AND ANGULAR MOMENTUM. Dixon, W. G. (Cambridge Univ., Eng.). Proc. Roy. Soc. (London), Ser. A: 314: 499-527(27 Jan 1970).

Definitions are proposed for the total momentum vector $p^{\alpha}$ and spin tensor $S^{\alpha\beta}$ of an extended body in arbitrary gravitational and electromagnetic fields. These are based on the requirement that a symmetry of the external fields should imply conservation of a corresponding component of momentum and spin. The particular case of a test body in a de Sitter universe is considered in detail, and used to support the definition $p_{\beta}S^{\alpha\beta} = 0$ for the center of mass. The total rest energy M is defined as the length of the momentum vector. Using equations of motion to be derived in subsequent papers on the basis of these definitions, the time dependence of M is studied, and shown to be expressible as the sum of two contributions, the change in a potential energy function $\phi$ and a term representing energy inductively absorbed, as in Bondi's illustration of Tweedledum and Tweedledee. For a body satisfying certain conditions described as "dynamical rigidity," there exists, for motion in arbitrary external fields, a mass constant m such that $M = m + \frac{1}{2}S^{\kappa}\Omega_{\kappa} + \phi$, where $\Omega_{\kappa}$ is the angular velocity of the body and $S^{\kappa}$ its spin vector. (auth) (UK)

## Scattering Theory

*Refer also to abstract 15663.*

**15677** (INP-681, pp 81-101) QUASIPOTENTIAL METHOD IN THE BOUND STATE PROBLEM. Faustov, R. (Joint Inst. for Nuclear Research, Dubna (USSR)).

The quasipotential equation, which is used for the elastic scattering amplitude at high energies, local currents of composite particles, and energy levels of hydrogen-like systems in quantum electrodynamics, is discussed. General properties of this equation and bound state matrix elements of local operators are considered. (J.F.P.)

**15678** (INP-681, pp 103-25) PHASE OPERATOR IN THE SCATTERING THEORY. Bialynicki-Birula, I. (Warsaw Univ. (Poland). Inst. of Theoretical Physics).

An unusual representation of the S-operator is described, and some of its applications are discussed. This representation is of the exponential form $S = e^{i\Phi/\hbar}$, where $\Phi$ is the phase operator. The perturbation expansion for $\Phi$, the application to relativistic two-channel scattering of spinless particles, and the phase and quasi-classical approximation are discussed. (J.F.P.)

**15679** MATHEMATICAL AND PHENOMENOLOGICAL DUALITY. Oehme, R. Nucl. Phys.; B16: 161-77(1970).

The concepts of mathematical and phenomenological duality of binary amplitudes are considered at first in the meromorphic limit. It is shown that mathematical duality is essentially a consequence of the requirement of Regge boundedness of all parts of the amplitude in directions not parallel to the real axes. The role of duality in the presence of unitarity branch lines is discussed and the importance of empty cuts for the construction of interference-type models is emphasized. The approximate expansion of an amplitude into a finite number of pole terms in all channels simultaneously is explored briefly. (auth)

**15680** BOUND-STATE CONDITIONS FROM THE $ND^{-1}$ EQUATIONS. Rosdolsky, H. G. (Univ. of Oregon, Eugene). Nuovo Cim.; 65A: 491-510(1 Feb 1970).

Conditions on the input to the matrix $ND^{-1}$ equations for a bound state with given mass and couplings are derived. For n dynamically coupled channels there are n + 1 conditions, n of which are essentially algebraic. (auth)

**15681** WARD-LIKE IDENTITIES AND TWISTING OPERATOR IN DUAL RESONANCE MODELS. Gliozzi, F. (Istituto Nazionale di Fisica Nucleare, Turin). Lett. Nuovo Cim.; 2: 846-50(21 Dec 1969).

A set of Ward-like identities is deduced in a very simple form by using the operational formalism recently proposed by Fubini, Gordon, and Veneziano. The identities ensure automatically the reflection symmetry of the general n-point functions. (L.B.S.)

**15682** ENHANCEMENT EFFECT AND CONTRIBUTION FROM ENHANCED REGGEON GRAPHS AT AVAILABLE ENERGIES. Ter-Martirosyan, K. A. (Inst. of Theoretical and Experimental Physics, Moscow). Yadern. Fiz.; 10: 1262-75(1969). (In Russian).

The contribution from the simplest and most essential enhanced graphs resulting from the account of the Regge-type behavior of the reggeon-particle scattering amplitudes is calculated. The calculations are performed in the energy representation at available energies where the result depends on the explicit form of different vertex parts contained in the theory. The simplest assumption about the Gaussian shape of vertex parts is made. The results are obtained in the form appropriate for direct comparison with the experimental data. (auth)

**15683** DYNAMICAL CALCULATION OF REGGE TRAJECTORIES. Degasperis, A.; Predazzi, E. (Indiana Univ., Bloomington). Nuovo Cim.; 65A: 764-82(21 Feb 1970).

The possibility of dynamical constructing a Regge trajectory $\alpha(s)$ is investigated under the assumption that it satisfies a once-subtracted dispersion relation. This implies a departure of $\alpha(s)$ from a pure straight line behavior at sufficiently large $|s|$. This departure is shown to be connected to the rate of growth of the resonance-width function (which interpolates among the experimental width of the resonances lying on the Regge trajectory) and turns out to be very small, in agreement with the present data on resonant states. (auth)

**15684** WEAK DUALITY AND THE ASYMPTOTIC DETERMINATION OF MASS SPECTRA. Atkinson, D. (Imperial Coll. of Science and Tech., London); Dietz, K. Nuovo Cim.; 65A: 683-8(21 Feb 1970).

A concept of "weak duality" is expounded according to which a generalized Regge-pole term is constrained to exhibit high-energy Regge behavior in two different channels. It is shown that, if log A(s,t) has a uniform power bound in s, for all t, and if A(s,t) is weakly dual, then the leading Regge trajectory and residue are asymptotically determined. (auth)

**15685** MASSLESS PARTICLES AND ANALYTIC CONTINUATION IN MASS. Barut, A. O. (International Centre for Theoretical Physics, Trieste, Italy). Acta Phys. Austr.; Suppl. 6, 1-18 (1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The limit from a massive particle ($m \neq 0$) to a massless particle ($m = 0$) is a discontinuous one. The gauge conditions allow one to perform this continuous limit and give conditions on the coupling constants and amplitudes at the points $m = 0$. It is useful to start with the $m \neq 0$ amplitudes, to introduce the notion of analytic continuation in mass, and then obtain the values of some of these amplitudes at $m = 0$ by the gauge conditions. For physical massless particles this process gives the values of the amplitudes in the physical region, for other particles outside the physical region. The so-called "self-consistency" conditions previously obtained from PCAC are derived by such a process of analytic continuation in mass, and some new results on form factors are obtained. Furthermore, some implications of the rather powerful spin-½ gauge conditions for leptonic weak decays which do not seem to have been realized before are discussed. (auth)

**15686** FINITE ENERGY SUM RULES: USE AND INTERPRETATION. Horn, D. (Tel Aviv Univ., Israel). Acta Phys. Austr.; Suppl. 6, 124-56(1969).

From 8th International Conference on Particle Physics, Schladming, Austria. See CONF-690219.

The finite energy sum rules are derived and are studied for certain physical amplitudes in order to see their relevance and implications to recent bootstrap programs. The applications to $A^{1(-)}$ at $t = 0$ and to $B^{(-)}$ amplitude of $\pi N$ scattering are discussed. Attention is paid to the problem of various fixed poles. The concept of duality and its use in bootstrap calculations are discussed. The last sections are devoted to Veneziano's formula and recent developments. (L.B.S.)

**15687** THEORY OF COMPLEX ANGULAR MOMENTUM: PAST AND FUTURE. Cheng, Hung (Massachusetts Inst. of Tech., Cambridge). Stud. Appl. Math.; 48: 341-9(Dec 1969).

Three fundamental subjects on Regge poles are discussed.

They are: the relation between the Mandelstam representation and the theory of complex angular momentum; the validity of the Regge asymptotic form for a general, complex s, (which includes the physical region of the t channel as a special case); a major obstacle in the future of Regge poles as a complete scheme of dynamical calculations. (auth)

**15688** NUCLEAR-BINDING CORRECTION TO THE SCATTERING AMPLITUDE AT INTERMEDIATE ENERGY. Kohmura, Toshitake (Univ. of Rochester, N. Y.). Phys. Rev.; 187: 1233-8(20 Nov 1969).

The correction to the nucleon scattering amplitude induced by the nuclear-binding potential is analyzed. The result shows that the nuclear-binding potential corrects the nucleon-nucleon scattering amplitude, i.e., its absolute value, by 2% and its phase by 2° in the case of 1-GeV proton scattering from $^4$He. Thus, the correction to the absolute value is negligible, but the ratio of the real and imaginary parts of the scattering amplitude is appreciably changed. The correction varies with the incident energy and the momentum transfer. Therefore, the angular distributions of proton scattering from nuclei are not corrected very much, except at the minima. The depth of the first minimum is affected, since it is very sensitive to the phase of the scattering amplitude. The result is consistent with the experimental results which indicate that the first minimum may be absent in proton scattering from deuterons, and that, on the other hand, the minimum is clearly manifested in scattering from $^4$He, $^{12}$C, and $^{16}$O. The values of the phase of the nucleon scattering amplitude, for the best fits to the experiments, are different from its value for scattering from nucleons. (auth)

**15689** TCP SIGNATURE AND NON-COMPACT COVARIANCE CONDITIONS IN CROSSED PARTIAL WAVE ANALYSIS: THE THREE-REGGEON VERTEX. Goddard, P.; White, A. R. (Cambrige Univ., Eng.). Nucl. Phys.; B17: 45-87(1970).

The incorporation of TCP invariance and the definition of TCP signatured partial wave expansions of multiparticle amplitudes are considered. The partial wave analysis of the six-particle amplitude involving a "three-Reggeon" vertex is studied in detail. Two forms of covariance condition, associated with this vertex, are found to occur. In one case the covariance group is non-compact so that the amplitude can not be square integrable. The usual theorems do not directly apply. However it is shown that the partial wave coefficients still converge and the expansion theorem holds; the significance of this is examined in detail leading to the full incorporation of the covariance conditions in the partial wave coefficients. The specification of limits in terms of invariants is also considered. (auth)

**15690** THE THREE-REGGEON VERTEX: ANALYTICITY, ASYMPTOTICS, AND THE TOLLER POLE MODEL. Goddard, P.; White, A. R. (Cambridge Univ., Eng.). Nucl. Phys.; B17: 88-116(1970).

The incorporation of the local analyticity properties of the six-particle amplitude in a previous treatment of the three-Reggeon vertex is considered. A triple Regge pole contribution is shown to be singular on the boundary between two parts of the physical region where the partial-wave expansion was shown to take different forms. This singularity can be removed by appropriate behavior of the residue function, but the asymptotic region where the pole contribution can be expected to dominate behaves unsatisfactorily. For comparison, the connection between the singularity of a Regge pole contribution and the bad behavior of the asymptotic region is also discussed for the zero momentum transfer problem. Analytic group variables, uniformly related to the invariants are introduced for the six-particle amplitude. A Lorentz-group expansion incorporating the vertex covariance condition is given and a triple Toller pole is shown to be a possible uniform asymptotic approximation to the amplitude in the neighborhood of the boundary considered. The treatment of the three-Reggeon vertex is used to give a full group theoretic treatment of an arbitrary multiparticle amplitude. (auth)

**15691** DAUGHTER POLES IN REGGEIZED HELICITY AMPLITUDES AT s = 0. Cosslett, S. R. (Princeton Univ., N. J.). Nuovo Cim.; 66A: 57-103(1 Mar 1970).

Daughter and conspirator Regge poles are considered at s = 0 in UU and UE scattering of particles of arbitrary spin. General expressions are obtained for the daughter residues to the lowest order in s that is compatible with analyticity and factorization requirements, and expressions for the sum of these lowest-order contributions to an arbitrary helicity amplitude. The daughter residues in EE scattering can be obtained by factorization, and, in the cases when the lowest allowed order of s is zero, Toller poles with general values of M are found. In other cases, daughter sequences similar but not identical to those of a Toller pole are found. Trajectory slopes at s = 0 are also obtained for arbitrary M. (auth)

**15692** CONSTRAINTS ON THE REAL PART OF THE SCATTERING AMPLITUDE FROM POSITIVITY AND BOUNDEDNESS OF THE IMAGINARY PART. Cornille, H. (CEN de Saclay, Gif-sur-Yvette, France). Nuovo Cim.; 66A: 217-37(1 Mar 1970)

Some constraints on the real part of scattering amplitudes due to positivity properties and bounds of the imaginary part are investigated. The method used consists in writing systematically sum rules for functions associated with the scattering amplitude and where the discontinuities along the cuts are linear combinations of the real and imaginary parts with known weight functions. (auth)

**15693** STATISTICAL PROPERTIES OF THE LEVEL STRUCTURE IN DUAL-RESONANCE MODELS. Corgnier, L.; D'Adda, A. (Univ., Turin). Nuovo Cim.; 66A: 253-60(1 Mar 1970).

The level structure of dual-resonance models is investigated by using statistical techniques. The average values of $L^2$ and of the invariants of the Lorentz group on an energy level are calculated. (auth)

**15694** VARIATIONAL ESTIMATES OF IMPACT-PARAMETER AMPLITUDES. Hahn, Yukap (Univ. of Connecticut, Storrs). Phys. Rev.; 187: 1365-8(20 Nov 1969).

The high-energy impact-parameter amplitude is estimated variationally for a simple potential scattering, using the local-bound property of the reduced zero-energy operator. The result shows that the method may be effectively applied to composite-system scatterings with or without particle exchanges, and also to scattering problems at lower energies. (auth)

**15695** CROSSING RELATIONS FOR HELICITY AMPLITUDES. Hara, Yasuo (Tokyo Univ. of Education). J. Math. Phys. (N. Y.); 11: 253-7(Jan 1970).

Crossing relations between s-channel helicity amplitudes and u-channel helicity amplitudes are derived, following the derivation of the crossing relations between s-channel helicity amplitudes and t-channel helicity amplitudes by Trueman and Wick [T. L. Trueman and G.-C. Wick, Ann. Phys. (N. Y.) 26: 322 (1964)]. The over-all phase factor of crossing relations, which was not given by Trueman and Wick, is also derived by specifying the path of analytic continuation and by applying these relations in the static approximation. (auth)

**15696** EXACT SOLUTION OF THE FADDEEV EQUATIONS FOR A ONE-DIMENSIONAL SYSTEM. Dodd, L. R. (Univ. of Adelaide). J. Math. Phys. (N. Y.); 11: 207-13(Jan 1970).

The Faddeev equations for the one-dimensional system consisting of three identical particles interacting through $\delta$-function potentials are shown to be exactly solvable. The scattering solutions in the form of half-off-shell rearrangement and elastic amplitudes are constructed explicitly and the ground state of the system is derived. (auth)

**15697** CONNECTION BETWEEN MARCHENKO FORMALISM AND N/D EQUATIONS: REGULAR INTERACTIONS. II. Cornille, Henri (Institut de Physique Nucleaire, Orsay, France). J. Math. Phys. (N. Y.); 11: 61-78(Jan 1970).

In a previous paper it was shown, for S-waves, that the resulting integral equations of the f/f equations (equivalent to the N/D approach) can be obtained from the Marchenko formalism. The potential $V(\mu,r)$ reconstructed from the discontinuity $\mu\Delta(x)$ is $-2(d/dr)[(d\mathcal{D}/dr)/\mathcal{D}]$, where $\mathcal{D}(\mu,r)$ is the Fredholm denominator of the Jost solution and $\mathcal{D}(\mu,0)$ that of the resulting integral equation. For "regular discontinuities" different classes of $V(\mu,r)$ are found. First, if $\mathcal{D}(\mu,0) = 0$, then $V(\mu,r)$ is not "regular at the origin" [in general, it is found that $V(\mu,r)$ becomes marginally singular: repulsive and singular like $r^{-2}$]. Secondly, if $\mathcal{D}(\mu,0) \neq 0$, then $V(\mu,r)$ is "regular" at the origin and the following are obtained: (i) If $|\mu|$ is less than the smallest modulus root of $\mathcal{D}(\mu,0)$, then $V(\mu,r)$ has no poles for $r \geq 0$. This range of $|\mu|$-values where the iteration series of the resulting integral equations converge is limited by the smallest $|\mu|$ value where a real or complex ghost can appear or where a bound state can appear at zero energy. (ii) For $|\mu|$ larger than this smallest modulus root but $\mu$ inside the interval given by the first positive and negative roots, $V(\mu,r)$ has no second-order poles for $r \geq 0$. These results (i) and (ii) are obtained with the restriction that in the considered interval there do not exist $(\mu,r)$-values such that $\mathcal{D}(\pm\mu,r) = 0$, and from this study it cannot be concluded that this is always true. (iii) For $\mu$ outside the above interval, $V(\mu,r)$ has poles of the second order for $r > 0$, the "bound states" being, in general, real or complex ghosts, or "bound states" corresponding to badly behaved potentials. It is also found that the Jost solutions for energy equal to zero are $\mathcal{D}(-\mu,r)/\mathcal{D}(\mu,r)$. This gives the connection between ghosts and, in general, possible bound states appearing at zero energy; this gives also the relations between poles of $V(\mu,r)$ corresponding to opposite $\mu$ values. These results for the Jost function correspond to a normalization at infinity, so the problem of subtractions with nor-

malization at an arbitrary point was considered. Then the new Fredholm determinant is the product of the old one by the value of the Jost function at the subtracted point. It follows that, if the first $\mu$-greater-than-zero and the first $\mu$-less-than-zero roots of $\mathcal{D}(\mu,r)$ are not opposite ($r \geq 0$), the $|\mu|$ interval of convergence of the iteration series is enlarged for the subtracted equation. (auth)

**15698** LEGENDRE POLYNOMIAL EXPANSIONS OF HYPERGEOMETRIC FUNCTIONS WITH APPLICATIONS. Holdeman, Jonas T. Jr. (Los Alamos Scientific Lab., N. Mex.). J. Math. Phys. (N. Y.); 11: 114-17(Jan 1970).

The expansion of a class of hypergeometric functions in a series of Legendre polynomials is derived. The range of validity and the meaning to be attached to the sums are investigated. Several applications to the problem of the scattering of charged particles are presented. (auth)

**15699** NEW METHOD FOR FINDING EIGENVALUES. Anderson, J. T. (Queen's Coll., Flushing, N. Y.). J. Math. Phys. (N. Y.); 11: 117-24(Jan 1970).

The eigenvalue equation of a function of a single complex variable is shown to be equivalent to the Cauchy–Riemann equations so that the eigenvalue problem is reducible to the problem of finding the analytic regions of the function. The eigenvalues of a function of several complex variables are also found from the analytic regions on each plane. A self-consistent treatment of two relativistic fields is developed and applied to the interaction of spinor and scalar fields. (auth)

## Particle Accelerators

*Refer also to abstracts 13919, 14344, 14350, 14361, 15766, and 15867.*

**15700** (ANL-Trans-805) ONE MORE POSSIBLE METHOD OF HEAVY ION ACCELERATION. Tarantin, N. I. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated for Argonne National Lab., Ill., from report JINR-P9-4555. 10p. Dep. CFSTI.

A method of acceleration of heavy ions in the cyclotron when ions are stripped in the process of acceleration, is suggested. Sufficiently intense and monoenergetic beams of heavy ions of wide set (from argon ions to uranium ions), having the energy about 10 MeV per nucleon, can be obtained in the cyclotron of relatively moderate dimensions (the final orbit radius being R = 200 cm). (auth)

**15701** (BNL-14330) CORRECTION OF THE ORBIT IN A SECTION OF THE AGS RING. Vogel, U. (Brookhaven National Lab., Upton, N. Y.). 23 Dec 1969. 17p. Dep. CFSTI.

The application of a computational method for derivation of orbit perturbations from pick-up electrode readings for automatic control of the AGS ring magnet positions is described. The magnet derivations within a given section of the ring are considered, and the orbit is compensated for to follow the magnet centerline closely and indicate zero readings in the pick-up electrodes. (W.H.K.)

**15702** (CEA-CONF-1384) PLASMA EXPANSION CHAMBER IN AN ION SOURCE OF THE DUOPLASMATRON TYPE. Bex, L.; Faure, J.; Vienet, R. ([Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires]). [nd]. 3p. (In French). (CONF-690625-5). Dep. CFSTI (U. S. Sales Only).

From International Conference on Ion Sources, Saclay, France.

The radial density, the intensity, and the emittance of a beam of protons from a duoplasmatron-type source were studied using an expansion chamber which is isolated so as to polarize it at the electric potential required with respect to the anode potential. The walls were without deposits and were perfectly conducting. The effect of the leak magnetic field and the length of the expansion chamber were studied. The data obtained are tabulated. (J.S.R.)

**15703** (CEA-CONF-1433) GAS AND DUST ACTIVATION IN THE TARGET ROOM OF THE SACLAY ELECTRON LINAC. IDENTIFICATION OF THE PRODUCED RADIOACTIVE NUCLEI AND DETERMINATION OF THE REJECTED ACTIVITIES. Vialettes, H. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [nd]. 17p. (CONF-691101-13). Dep. CFSTI (U. S. Sales Only).

From 2nd International Conference on Accelerator Dosimetry and Experience, Stanford, Calif.

The first runs of the Saclay Electron Linac (A.L.S.) with high power beam (330 to 560 MeV, 100 kW on the target) held from July to November 1968 are considered. During this time, the usual checks of the shielding efficiency were made, and the problem of gas and dust activation in the room where the beam reaches the target was studied. The first study to identify the radioactive nuclei produced and to estimate the risks for people entering the target room immediately after the shut-down of the accelerator or for people staying in the cloud emerging from the stack is described. It can be seen that most frequently encountered radionuclides are: $^{13}N$, $^{15}O$, $^{11}C$, $^{41}Ar$, $^{38}Cl$, $^{38}Cl$, $^{7}Be$, $^{24}Na$, $^{57}Ni$, $^{56}Mn$, and $^{159}Gd$. All these radionuclides have been identified by their $\gamma$-spectrum and half-life. The devices used for air sampling and analyzing and the interpretation of the results to determine the concentration of rejected active products are discussed. For radioactive gas, it is possible to measure instantaneously the rejected activities expressed in Maximum Permissible Concentration (M.P.C.). For dusts, the calibration is expressed in M.P.C. for active nuclei having short half-life and M.P.C. hour for active nuclei having a long half-life. (auth)

**15704** (CEA-N-1110) CALCULATION OF 3rd-ORDER GEOMETRICAL ABERRATIONS IN QUADRUPOLE LENS SYSTEMS. Tanguy, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Jan 1970. 108p. (In French). Dep. CFSTI (U. S. Sales Only).

Analytical expressions for the aberration coefficients of quadrupoles are set up for various forms of their characteristic function. The results obtained are used to calculate the aberration coefficients of an arbitrary quadrupole lens system; these coefficients may be used to estimate the importance of aberrations in beam transport systems. A program has been set up to compute the aberration coefficients of an arbitrary quadrupole system. This program does not require numerical integrations and yields accurate values for the aberration coefficients very quickly. (auth) (France)

**15705** (CEA-N-1248) HIGH-ENERGY AND HIGH-RESOLUTION SPECTROMETRY USING THE SATURNE BEAM. Thirion, Jacques; Birien, Paul; Saudinos, Jean (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Jan 1970. 80p. (In French). Dep. CFSTI (U. S. Sales Only).

In order to do nuclear physics with particles from the proton synchrotron Saturne in the 1 GeV energy range, a magnetic spectrometer has been designed to give an energy resolution $\Delta E/E \simeq 10^{-4}$. Because of its natural energy dispersion ($\pm 10^{-3}$), the incident beam on target must be magnetically analyzed. The compensation of incident energy dispersion, the elimination of the dispersion due to kinematic effects, and the correction of the geometrical aberrations are described. Characteristics of the different magnets are given and the procedures to get the correct magnetic fields are described. (auth)

**15706** (CERN-69-28, pp 13-31) THE CERN NEUTRINO BEAM. Pattison, J. B. M. (European Organization for Nuclear Research, Geneva (Switzerland)).

The discussion of the CERN neutrino beam includes the 1967 neutrino installation, neutrino beam monitoring, experimental results, and future improvements to this neutrino beam. (J.F.P.)

**15707** (CERN-69-28, pp 33-46) THE NEUTRINO SPECTRUM FOR THE CERN 1967 NEUTRINO EXPERIMENT. Wachsmuth, H. W. (European Organization for Nuclear Research, Geneva (Switzerland)).

The method for obtaining the neutrino spectrum is briefly described. This neutrino spectrum is presented and compared with previous predictions. (J.F.P.)

**15708** (CERN-69-28, pp 47-53) UPPER LIMIT OF THE $\bar{\nu}$-CONTAMINATION IN THE CERN NEUTRINO BEAM. Borer, K.; Hahn, B.; Hofer, H.; Kaspar, H.; Krienen, F.; Seiler, P.-G. ([Bern Univ. (Switzerland)]).

An upper limit for $\bar{\nu}$ contamination of the CERN neutrino beam at the detector is determined from a previous experiment using the CERN neutrino beam. For this purpose lepton conservation is assumed to hold and also the absence of $\mu^+$ sources other than from $\pi^-(K^-) \rightarrow \mu^- + \bar{\nu}_\mu$ interactions and $\bar{\nu}_\mu$ reactions with a nucleus yielding $\mu^\pm$. Spark chambers and the CERN propane bubble chamber are used to study this $\bar{\nu}$ contamination. The ratios of $\mu^+/\mu^-$ and an upper limit for $\bar{\nu}/\nu$ are given. (J.F.P.)

**15709** (CERN-69-28, pp 55-8) SPATIAL DISTRIBUTION OF HIGH-ENERGETIC NEUTRINOS IN THE 1967 CERN NEUTRINO BEAM. Borer, K.; Seiler, P.-G. (Bern Univ. (Switzerland)).

A spark chamber setup was exposed to a neutrino beam, for which the spatial distribution was previously calculated. The calculations were checked experimentally by means of the startpoint distribution of the neutrino events in the spark chamber. Other than a slight asymmetry of the beam, good agreement with the calculations was found. (J.F.P.)

**15710** (CERN-69-28, pp 59-66) SCALING THE CERN NEUTRINO BEAM TO HIGHER ENERGIES. Venus, W. A.

(European Organization for Nuclear Research, Geneva (Switzerland)).

Possibilities of scaling up the present CERN wide-band neutrino beam design for installation at higher-energy accelerators are given. These methods can also be applied to the scaling of other beam designs. The design philosophy of the CERN neutrino beam, approximations, and energy scaling law are covered. (J.F.P.)

**15711** (CERN–69-28, pp 67-77) NEUTRINO FACILITY PLANS AT NAL. Nezrick, F. A.; Read, A. L. (National Accelerator Lab., Batavia, Ill.).

Physics experiments will begin at NAL in July 1972 when a 200 GeV proton beam will be available at experimental area No. 1. Soon thereafter, neutrino physics could also begin in the neutrino area with counter-spark chamber experiments but with an unfocussed neutrino beam. After a particle survey in experimental area No. 1, the focussing elements can be constructed. Experiments using a focussed neutrino beam with the 25-foot bubble chamber could begin at the end of 1973. (auth)

**15712** (CERN–69-28, pp 79-80) NEUTRINO EXPERIMENTS AT SERPUKHOV. Kuznetsov, E. P. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii).

The development of neutrino experimental facilities at Serpukov is described. The neutrino spectra, the experimental arrangement, and physics are discussed. (J.F.P.)

**15713** (CERN-Trans–69-29) GAS TARGET FOR SLOW MESON EXPERIMENTS. Ermolov, P. F.; Lepilov, V. I.; Mukhin, A. I. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated by B. Hodge (CERN, Geneva, Switzerland), from report JINR–P-2711. 5p. Dep. CFSTI (U. S. Sales Only).

An abstract of this paper, prepared from the original language, appeared as NSA 20: 34152. (W.H.K.)

**15714** (CONF-680520–, pp 22-40) A HIGH-VOLTAGE PULSE-TRAIN AMPLIFIER FOR 10-MHz LINAC BEAM MODULATION. Nylander, R. F. (Varian Associates, Palo Alto, Calif.).

Electrostatic deflection plates driven by thyratrons have been used to produce beam pulses as short as 3 ns in several Varian linear accelerator systems. However, for the Frascati ring experiment, in which 300 MeV electrons and positrons are circulated in opposite directions prior to their mutual annihilation, it was desirable to produce a burst of short pulses to concentrate the charge within an azimuthally limited portion of the ring and thereby increase its efficiency. To accomplish this, a unique vacuum-tube amplifier was developed that was capable of producing a 1200-volt, 10-MHz pulse train with a 30% duty factor during the 3-$\mu$s burst. 10 to 90% rise and fall times of approximately 5 ns were achieved with continuous remote pulse-width control out to the full 3 $\mu$s. Unusual design features and preliminary performance data are discussed. (auth)

**15715** (DESY–69/52) PARTICLE LOSS THROUGH SCATTERING OF SYNCHROTRON RADIATION. Piwinski, A. (Deutsches Elektronen-Synchrotron, Hamburg (West Germany)). Dec 1969. 16p. (In German). Dep. CFSTI (U. S. Sales Only).

It is shown that in electron and positron storage rings at high energies the scattering of the synchrotron radiation on particles in the same bunch can lead to particle losses. With increasing energy and particle density this effect is a sharp limit for the stored beam current. (auth)

**15716** (EUR–4290, pp 1-4) DATA HANDLING AND ON-LINE COMPUTING IN THE OXFORD ELECTROSTATIC GENERATOR LABORATORY. Allen, K. W. (Oxford Univ. (England). Nuclear Physics Lab.).

The evolution of the Oxford data handling system which is time shared by two on-line electrostatic accelerator facilities is briefly discussed. Experience with the system, front-end hardware, and future developments are outlined. (W.H.K.)

**15717** (JINR–P9-4851) MEASUREMENT OF THE ELECTRICAL FIELD IN THE CENTRAL REGION OF THE DUBNA SYNCHROCYCLOTRON BY THE INDUCED CURRENT METHOD. Pronin, V. P.; Safonov, A. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1969. 16p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The components of the electric field in the central region of the Dubna synchrocyclotron have been found by the induced current method which is based on the measurement of charge and current induced on the plates when either a point charge (a charge probe) or a probe vibrating at a constant frequency are placed into the point under investigation. A model in 1:5 scale has been used for measuring the components of the accelerating and electrostatic fields of the dee and the focusing plates in the presence of a bar imitating the plasma column. The measurement data are tabulated and can be used in calculating particle motion by computer. (auth)

**15718** (JINR–P9-4852) ON THE OPTIMAL GEOMETRY OF THE SYNCHROCYCLOTRON CENTRAL REGION. Vinokurov, V. I.; Safonov, A. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1969. 29p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The effect of the feeler position screening the semi-circular cut in the dee near the ion source and of the distance to the plates producing additional vertical focusing as well as the influence of their shape for a dee aperture of 8, 12, 18, and 24 cm on the vertical electrostatic forces has been studied. The vertical forces due to the negative bias over the dee and due to the negative potential applied to the focusing electrodes have been measured by using the electrolytic tank with a 1:2 scale model. The plasma of the open ion source and the hood of the closed one are supposed to be at the ground potential. The dependence of the maximum possible particle energy gain per turn upon the orbit radius has been calculated by means of the potential line pattern. It has been established that the electrostatic forces due to the dee bias become defocusing, while the energy gain per turn is somewhat increased if a semi-circular cut in the dee is screened with a feeler. It has been established that near the source (r = 2 to 4 cm) the focusing due to the bias has an optimum when the dee aperture is 15 to 18 cm, while the additional electrostatic focusing is largest when the focusing electrodes have a cut of $R_{fe}$ = 10 cm. The accelerating field has a defocusing effect of the same order of magnitude, as that of dee bias. The obtained results can be used for the determination of optimal conditions for acceleration in the cyclotron central region. (auth)

**15719** (LA–4276) FABRICATION OF 201.25-MHz DRIFT-TUBE LINAC QUADRUPOLE MAGNETS. Bush, E. D. Jr. (Los Alamos Scientific Lab., N. Mex.). 4 Jun 1969. Contract W-7405-eng-36. 38p. Dep. CFSTI.

The fabrication techniques adopted for manufacture of the quadrupole magnets for the drift-tube linac are presented. The resulting magnets have two unique features; they can withstand repeated brazing at 1500°F, and they are highly resistant to radiation damage. (auth)

**15720** (RISO–M–974) SYSTEM FOR HORIZONTAL BENDING OF THE ELECTRON BEAM OF THE LINEAR ACCELERATOR. Lynggard, B. (Danish Atomic Energy Commission, Risoe. Research Establishment). Nov 1969. 6p. (In Danish). Dep. CFSTI (U. S. Sales Only).

Calculations are given for a bending coil, and the stabilized current source (variable from −2 to +2 amperes) is described in principle. (Denmark)

**15721** (SLAC–112) TWO-MILE ACCELERATOR PROJECT. Quarterly Status Report, July 1–September 30, 1969. (Stanford Linear Accelerator Center, Calif.). Dec 1969. Contract AT-(04-3)-515. 65p. Dep. CFSTI.

A status report on the Stanford Linear Accelerator Project covering the period July 1, 1969 to September 30, 1969 is presented. Topics included are accelerator and research area operations, accelerator and research area equipment development, and physics research equipment development. (auth)

**15722** (SLAC-Trans–109) PROGRESS REPORT ON THE 3.5 GeV ELECTRON-POSITRON COLLIDING-BEAM INSTALLATION (VEPP-3). Budker, G. I.; Protopopov, I. Ya.; Skrinskii, A. N. Translated by T. Watt for Stanford Linear Accelerator Center, Calif., from Sostoyanie Rabot na Ustanovke so Vstrechnymi Elektron-Pozitronnymi Puchkami na Energiyu 3,5 Gev (VEPP-3), Academy of Sciences, USSR, Novosibirsk, 1969. 14p. Dep. CFSTI.

The development of the 3.5 GeV electron–positron colliding beam installation VEPP-3 is outlined. The design parameters and construction status of the storage ring, vacuum chamber, high frequency system, synchrotron injector, and beam transport system are summarized. (W.H.K.)

**15723** (SLAC-Trans–111) CRYOGENIC HIGH-FREQUENCY ACCELERATING SYSTEM FOR A RINGOTRON. Anishchenko, N. G.; Alekseev, A. S.; Balalykin, N. I.; (and others) (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated by T. Watt for Stanford Linear Accelerator Center, Calif., from report JINR–P9-4722. 18p. Dep. CFSTI.

The choice of the main parameters of a cryogenic high-frequency accelerating system is discussed, and the basic construction elements of the system are described. Preliminary results of an investigation into the high-frequency properties of superconductors of the second kind are reported, and technological aspects of the production of superconducting resonator coatings are reviewed. (auth)

**15724** (TRI-69-5) MAGNET CORE CONSTRUCTION CONCEPT FOR A 500 MeV $H^-$ CYCLOTRON. Kiesners, U. (Dilworth, Secord, Meagher and Associates Ltd., Toronto (Ontario)). Jun 1969. 137p. Dep. CFSTI (U. S. Sales Only).

For TRI-Univ. Meson Facility, Vancouver (British Columbia).

The construction of the 4000-ton sector magnet cores for the TRIUMF cyclotron is described. The various considerations leading to the optimum design concept are discussed in detail. These include a study of the magnetic properties of commercial steels; the relative advantages of plates, forgings and castings; assembly methods such as bolting and welding; and an assessment of tolerances obtainable by flame cutting and machining. Economy considerations and delivery time have received major attention throughout the study. An important objective was to adapt the design, to the largest possible extent, to the capabilities of Canadian steel manufacturers and fabricators. A construction schedule and a cost estimate ($2,834,000) are included. (auth)

**15725** (TRI-69-9) CONCEPTUAL DESIGN STUDY FOR THE VACUUM PUMPING SYSTEM FOR A 500 MeV $H^-$ CYCLOTRON. Blakely, R. G.; Moore, R. W. Jr.; Harwood, Vivienne J. (TRI-Univ. Meson Facility, Vancouver (British Columbia)). Aug 1969. 142p. Dep. CFSTI (U. S. Sales Only).

The conceptual design study of the vacuum pumping system for the TRIUMF cyclotron considers two different pumping systems in detail: large trapped oil diffusion pumps, and 20°K cryopumps with auxiliary trapped oil diffusion pumps. The pumping systems are compared in relation to certain criteria. These include an equivalent nitrogen stripping cross-section pressure of $7 \times 10^{-8}$ Torr within 15 hours of pumping, minimum contamination of the vacuum chamber, and compatibility with other cyclotron components. Reliability, maintenance and test requirements have received particular attention, since cryopumping has not been widely used as a pumping method for an accelerator. A discussion of outgassing rate data of materials and an analysis of the gas loads for the cyclotron are included. Gauging and leak-testing methods for the vacuum chamber and pumping system are described. Estimates of capital and annual operating costs for the two pumping systems are provided, and a construction schedule is presented. (auth)

**15726** MEASUREMENT OF THE INTENSITY OF A BEAM OF ALPHA PARTICLES OF MEDIUM ENERGY (60 TO 160 MeV) AND OF ITS CONTAMINATION BY DEUTERONS. Bimbot, R.; Le Beyec, Y. (Faculte des Sciences, Paris. Faculte des Sciences, Orsay, France). Rev. Phys. Appl.; 4: 393-6(Sep 1969). (In French).

The intensity of the $\alpha$ particle beam is measured thanks to the activity induced in a gold target by the nuclear reaction $^{197}Au(\alpha, \alpha n)^{196}Au$. In this purpose, the absolute cross section of this reaction has been determined from 90 to 160 MeV. The high value of this cross section (about 100 mb) and its slow variation with incident energy make it very suitable to use this reaction as a beam monitor. When the presence of deuterons in the $\alpha$-particle beam is expected, the intensity of the deuteron beam can be measured by activation of a gold sheet after stopping the $\alpha$ component in a copper absorber foil. (auth)

**15727** A NEW METHOD FOR TRACING OF CHARGED PARTICLE TRAJECTORIES IN MAGNETIC SECTORS. Das, S.; Viswesvariah, M. N.; Sarma, N. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 142-4(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Basic equations for charged-particle trajectories in a magnetic field are presented for application to the case of a sector magnet. (W.H.K.)

**15728** POLARIZED PROTON TARGET AS A NEUTRON POLARIZER. Lushchikov, V. I.; Taran, Yu. V.; Shapiro, F. L. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 10: 1178-94(1969). (In Russian).

Theoretical basis for the method of neutron polarization by means of the penetration through a polarized proton target, is given. The neutron 65% polarization in the resonance energy region (up to several dozens of keV's) was obtained by means of this method with the La-Mg nitrate (LMN) monocrystal which decreases the neutron beam intensity by 5 times. The target square is 15 $cm^2$. The method is also effective for the polarization of thermal and cold neutrons. It provides an essential advantage in illumination as compared to the other methods known. Results of measurements of the energy dependence of the cross sections which determine the effect of the neutron polarizer with the LMN crystal, are given. (auth)

**15729** BEAM LOADING IN A HIGH-CURRENT STANDING WAVE ELECTRON ACCELERATOR. Stapleton, R. E.; Gritzo, L. A.; Venable, Douglas (Los Alamos Scientific Lab., N. M.). J. Appl. Phys.; 41: 82-8(Jan 1970).

Electron-beam loading of a single-cavity standing-wave accelerator has been investigated experimentally and theoretically for the case of continuous injection over ten cycles. The particular cavity used was a 2.4-m long right-circular cylinder excited at 50 MHz in its $TM_{010}$ mode with an unloaded Q of $1.2 \times 10^5$. Beam currents were varied from 40 to 210 A, field strengths from 0.2 to 6 MV/m, and the energy of the ejected beam from 1 to 10 MeV. During beam injection the energy supplied per cycle to the accelerator by its power amplifiers was negligibly small compared to the energy absorbed per cycle by the injected electron beam. The energy extracted by the electrons was determined from cycle-to-cycle oscilloscopic observations of the decay of the accelerating field. Energy extraction per cycle was as great as 8% of that residing in the electromagnetic field at the time of beam injection. The results agree with predictions over most of the range of the experimental parameters when assuming paraxial trajectories. Disagreement with calculations, when using the same assumption, arose when there were serious departures from paraxial flow. The special case of injection of a sharply bunched relativistic electron beam is also reported. Here each 18-MeV bunch contained about 1.7 $\mu$C and was about 6 nsec long. When in an accelerative mode the electric field was degraded and energy flowed from the field into the beam bunches at a rate of about 0.6 BW. However, when the phase of the field was reversed to establish a decelerative configuration the electric field was enhanced, energy flowed coherently from the beam bunches into the field at a rate of about 0.6 BW. Within experimental uncertainties, these values agree with predictions. (auth)

**15730** MEASUREMENTS OF PHASE BUNCHING IN ELECTRON LINACS BY RF DEFLECTOR. Toda, Tetsuo; Irie, Koichi; Nemoto, Yoshiaki (Mitsubishi Electric Corp., Amagasaki, Japan). Jap. J. Appl. Phys.; 8: 1535-9(Dec 1969).

A method for measuring directly the phase distribution of the electron bunch in linacs with a high phase resolution is presented. A bunched beam is introduced into an RF deflector of travelling wave type, which is synchronously excited with the same frequency as that of the linac. Deflection of electrons corresponds to their phase in the deflecting field. Electrons of near zero phase pass through the narrow slit placed on a line of the deflector. By means of a phase shifter, which controls input RF phase, the phase of the bunch as to the deflecting field is shifted and the phase spread of the bunch can be measured. The principle of the RF deflector used in this measurement is described fully. Phase resolution is discussed in detail and it is shown that the phase resolution of a few degrees is obtainable. Results of measurements are also reported. (auth)

**15731** PARAMETRIC RESONANCE CROSSING IN AN ACCELERATOR WITH INTENSE BEAMS. Balbekov, V. I.; Shukeilo, I. A. Zh. Tekh. Fiz.; 39: 1863-71(Oct 1969). (In Russian).

The process of betatron oscillation build-up in cyclic accelerators where the operation point, due to the electromagnetic–particle interaction, transverses the parametric resonance is studied. The charge density dependence on the position of the particle in the cluster induces multiple resonance crossing. An approximate solution was obtained for the betatron oscillations and particle losses. The general theory illustrated by concrete data can be applied to the Serpukhov 70 GeV synchrotron. (R.V.J.)

**15732** MONOENERGY CYCLOTRON. Glazov, A. A.; Denisov, Yu. N.; Dzhelepov, V. P.; Dmitrievskii, V. P.; Zamolodchikov, B. I.; Zaplatin, N. L.; Kolga, V. V.; Polikanov, S. M.; Solovev, V. G. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz.; 57: 1465-71(Nov 1969). (In Russian).

A special sectioned isochronous cyclotron with external injection for acceleration of p, d, $\alpha$, $^3He$ and $^6Li$ beams with a small energy spread ($10^{-4}$) and a peak proton energy of 80 MeV and intensity of 100 $\mu$A is considered. (auth)

**15733** LINEAR ELECTRON ACCELERATORS FOR USE IN INDUSTRY. Levin, V. M.; Myntyan, V. I.; Nikolaev, V. M.; Rumyantsev, V. V. (Research Inst. of Electrophysical Instruments, Leningrad). pp 627-32 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In Russian).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

For research purposes and for operating industrial processes for which electron beams of more than 5 MeV energy and with a beam power of more than 5 kW have to be used, the Scientific Research Institute for Electrophysical Equipment has developed four types of 8 to 15 MeV linear waveguide accelerators with a beam power of 5 to 10 kW. Klystrons are used to supply accelerators

of more than 7 kW power and magnetron oscillators are employed for accelerators of lower beam power. The accelerators are produced in two versions: for research purposes and for operation on industrial production lines. They are equipped with devices to scan or scatter the electron beam. The energy, spectrum and density distribution of the electron stream across the irradiation field are monitored periodically, and the accelerated electron current is checked continuously. The control desks of the accelerators are equipped with radiation timing devices which provide a continuous digital indication of the elapsed time. (auth)

15734 TECHNOLOGICAL ASPECTS OF THE INDUSTRIAL IRRADIATION OF RUBBER IN THE LATEX PHASE FOR THE PURPOSE OF PRE-VULCANIZATION BY AN ELECTRON ACCELERATOR. Icre, P. (Societe de Recherches Techniques et Industrielles, Boulogne-Billancourt, France). pp 643-60 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In French).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

As a result of this study, which was conducted in collaboration with the Radiation Applications Group, Centre d'études nucléaires, Saclay, it has been possible to design an industrial irradiation cell for continuous radiovulcanization of the natural-rubber latex. The irradiation circuit has been set up at CARIC (Centre for the Application of Ionizing Radiations, Corbeville), which is equipped with a linear electron accelerator having a mean power of 10 kW and energy of 6 MeV. The principle of this cell can be extended to the continuous treatment of any liquid, emulsion or suspension with an electron beam. The following are the main problems of such irradiation using a circulating liquid: (1) obtaining a homogeneous irradiation dose in the maximum mass of the irradiated product; (2) avoiding local overdosing; (3) irradiating with the optimum yield; (4) limiting the heating of the liquid treated; and (5) having apparatus for checking the parameters (cell and radiation). In particular, in the case of natural-rubber latex, points (2) and (4) are critical in view of the coagulation phenomena which occur as a result of overdosing and heating. The treatment cell is a stainless-steel semi-shell and consists of three sectors—feed-in, irradiation and clearance. The following design features are needed to solve all the problems stated above: the liquid circulates in the cell in the same direction as the sweep of the beam; the geometry of the irradiation sector is adapted to the beam geometry; the form and dimensions of the feed-in section are determined in such a way that the diagrams for the liquid flow rates can be superimposed on the curves depicting electron distribution in the beam; the irradiation sector is cooled by circulating water; the following values are recorded during the treatment—flow rate, level, liquid temperature and beam current. Under these conditions and for a mean electron beam power of 10 kW, it is possible to treat 2200 to 2500 litres of latex per hour at an average dose of 1.4 to 1.6 Mrad. This dose yields properly pre-vulcanized rubber, according to the study conducted by the Société MAPA and the Commissariat à l'énergie atomique. (auth)

15735 HIGH-CURRENT ELECTRON ACCELERATORS. Abramyan, E. A. (Inst. of Nuclear Physics, Novosibirsk, USSR). pp 661-70 of Large Radiation Sources for Industrial Processes. Vienna; International Atomic Energy Agency (1969). (In Russian).

From Symposium on Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany. See STI/PUB-236; CONF-690805.

The authors describe the utilization of high-current accelerators in industrial processing and research. (auth)

15736 THEORY CONCERNING THE ACTION OF RADIATION ON THE MOTION OF ELECTRONS IN ACCELERATORS. Baier, V. N.; Katkov, V. M. (Novosibirsk State Univ., USSR). Dokl. Akad. Nauk SSSR; 188: 56-9(1 Sep 1969). (In Russian).

In studying the interrelation of the classical and quantum-physical approaches to the influence of radiation on the motion of electrons in accelerators, it is proposed that radiation emission of high-energy particles in a given magnetic field be considered from a quantum-physical point of view. The magnetic bremsstrahlung induces 2 types of quantum effects: quantization of the motion of the electrons in the magnetic field, and the quantized emission of photons. For high-energy particles, quantization of the orbits in the accelerator may be neglected. An expression is presented for the probability of the emission of photons per unit time, deriving a quasiclassical generalization for the reaction of radiation. The equation obtained allows the determination of the action of radiation on the motion of a high-energy particle in a magnetic field. It was found that the character of the magnetic bremsstrahlung in accelerators may be affected by quantum effects, such as quantizing of orbits, forbidden transitions in potential wells, etc. (TTT)

15737 ACCELERATING DEVICE. Sakamoto, Teiichi. (to Nisshin Electric Co.). Japanese Patent 1969-15480. 9 Jul 1969. Filed 6 Sep 1965.

A Cockcroft–Walton accelerator is described, and the method and design are described for improved performance by pretreatment of the electrodes by producing potential between the electrodes before actual operation. (TSS) (NSA of Japan)

15738 RADIAL MOTION OF ELECTRONS INJECTED IN VERY SHORT BUNCHES IN A LINEAR ACCELERATOR. Bousoukaya, Mustapha; Septier, Albert (Paris Univ., Orsay, France). Compt. Rend., Ser. B; 270: 33-6(5 Jan 1970). (In French).

The equation of the trajectory of the test electron moving in synchronism with the accelerating wave in a low-current accelerator without any focusing magnetic field is analytically solved. The equation of motion of electrons injected near the test particle is established and numerically integrated. The beam emittance slightly increases when crossing the accelerator. (auth) (France)

15739 CONTRIBUTION OF OBLIQUELY SCATTERED ELECTRONS TO THE IRRADIATION UNDER THE SCANNER WINDOW. Okabe, Shigeru; Tabata, Tatsuo; Tsumori, Kunihiko; Ito, Rinsuke (Radiation Center of Osaka Prefecture). Jap. J. Appl. Phys.; 8: 1331-4(Nov 1969).

Directional distribution of electrons has been investigated for the case where they impinge on the sample after passing through the scanner window. A simple theoretical treatment to estimate the fractions of oblique electron flux is given. An experiment has also been made by using electrons of energies 1.5–8 MeV from a Van de Graaff and a linear accelerator. The calculated and the observed results have shown a moderately good agreement. It is to be noted that the contribution of the oblique flux with angle of incidence greater than 5° is about 15–65% under a typical irradiation geometry. (auth)

15740 CHARGED-PARTICLE PASSAGE THROUGH THREE-ELECTRODE DEFLECTING TELESCOPIC SYSTEMS. Bobykin, B. V.; Kel'man, V. M.; Nevinnyi, Yu. A.; Sekunova, L. M. (Alma Ata Inst. of Nuclear Physics, USSR). Zh. Tekh. Fiz.; 39: 1941-53(Nov 1969). (In Russian).

The vertical trajectory paths in three-electrode deflecting telescopic systems were studied on the basis of numerical calculations obtained with the third order precision. The obtained graphs indicate the positions of characteristic trajectory points distributed along the vertical plane projection. Three-electrode systems with the mean electrode width equal to 2.5, 3.5, 4.5, and 5.5 d (where d is the distance between the electrode plates) were examined. The ratio of effective potentials of the extreme electrodes varied from 15 to 150 for the accelerating systems and from $1/500$ to $1/15$ for the delay systems. (tr-auth)

15741 CORRELATION OF MICROTRON RESONATOR WITH THE WAVE-GUIDE TRACK. Matora, I. M.; Khar'yuzov, R. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Tekh. Fiz.; 39: 1997-2004(Nov 1969). (In Russian).

Stability conditions in a waveguide track of a microtron were analyzed. Formulas were obtained coupling the CSWL (coefficient of stationary wave load) in the waveguide track and the reliable resonator load. Theoretical curves and experimental data obtained during cold measurements and during microtron operation were correlated. The results showed that only one type of loading criteria can secure the necessary stable process of acceleration. (tr-auth)

15742 THEORY OF ELECTROMAGNETIC FIELD WITH AXIAL SYMMETRY FOR CYLINDRICAL VOLUME RESONATOR WITH CONDUCTING DISKS OR DRIFT TUBES. Andreev, V. G. Zh. Tekh. Fiz.; 39: 2011-17(Nov 1969). (In Russian).

Studies were made of the accelerating structure of a 250-MeV proton accelerator in the shape of a cylindrical resonator, loaded at equal intervals by conducting discs or drift tubes. A wave equation was obtained for the case in which such a resonator is excited with transverse magnetic-type oscillations with axial symmetry and from 0 to $\pi$ wave intervals. The obtained formula determines the relationship between the resonance wave length and the structure of the electromagnetic field and also determines the geometry of such resonators for arbitrary oscillations with the number of field variation according to coordinate z from 0 to N, where N is the number of discs or drift tubes in the resonator. An approximation method was developed for calculating resonator properties. (tr-auth)

15743 ACCELERATOR OUTPUT DEVICES. I. MAGNETIC ACHROMATIC ROTATING SYSTEMS. Belov, V. P.; Kokorin, A. M. Zh. Tekh. Fiz.; 39: 2018-28(Nov 1969). (In Russian).

Descriptions are given of a design of magnetic optical systems, capable of producing achromatic bending of the nonmonoenergetic beam and systems with compensating angular dispersion. The

obtained formulas and graphs are given in a convenient compact form for simple selection of the optimum scheme. (tr-auth)

**15744** PRELIMINARY BUNCHING IN STRONG-CURRENT LINEAR ION ACCELERATOR WITH LOW-ENERGY INJECTION. Enal'skii, V. A.; Osipov, V. V.; Fedotov, A. P.; Shembel, B. K. Zh. Tekh. Fiz.; 39: 2034-9(Nov 1969). (In Russian).

A mathematical simulation method was used in studies of intense proton beam bunching in a linear accelerator with a low injection energy. The feasibility of obtaining a high magnitude bunching factor during increased modulated intensity in the klystron-type buncher was analyzed. It was found that within certain limits, an increased straggling of bunched particle velocities do not interfere with the efficient capture of particle clusters in the synchronous mode due to the extended capture region inherent to such accelerators. (R.V.J.)

**15745** ELECTRON LOADING IN THE ACCELERATING TUBE OF THE ELECTROSTATIC ACCELERATOR. Terasawa, Michitaka (Tokyo Shibaura Electric Co., Kawasaki, Japan); Takayanagi, Sei-ichi; Murata, Tohru; Kawai, Nawoyuki; Matsuda, Yasuhiko; Mori, Masashi. Jap. J. Appl. Phys.; 8: 1324-30 (Nov 1969).

Measurements of the intensity of X-rays produced by electron loading and of the loading currents were made for two kinds of accelerating-tube of an electro-static accelerator as a function of terminal potential up to 4.0 MV. The distinct threshold and saturation of electron loading are observed in the case of little or no beam current, while they seem to have disappeared at least for one kind of the tube when much more beam is accelerated. It was found that a large fraction of X-rays was emitted as a train of intermittent bursts above the threshold. Duration of each burst was estimated to be about 40 msec. The threshold was raised by increasing gas pressure in the tube, when five kinds of gas— hydrogen, helium, nitrogen, neon and argon— were fed into the tube, and it was found that mono-atomic gases were more effective than diatomic gases. (auth)

**15746** CALCULATION METHOD FOR LINEAR ACCELERATOR WITH A STEADY PHASE VELOCITY. Teodorescu, I. E.; Petrashcu, E.; Vinitsan, I. Rev. Roum. Phys.; 14: 609-19 (1969). (In Russian).

An analytical calculation method is suggested for axial electron motion in an acceleration section with a constant phase rate considering the energy absorbed by the beam. The electron trajectories in the phase space offer a sufficiently accurate picture of the acceleration process, indicating that the capture efficiency is not a function of the amount of accelerator current load. It is shown that the maximum capture took place with the highest phase excursion magnitudes. Moreover, during this period the low-energy beam component was also reduced. The described method can be applied to high-energy sections of proton accelerators with waveguides. (tr-auth)

**15747** METHOD FOR MEASUREMENT OF INSTANTANEOUS VALUES OF BEAM COORDINATES IN AN ACCELERATOR CHAMBER. Babayan, A. Z.; Vartanyan, G. S.; Karabekov, I. P.; Nazaryan, Yu. P. (Inst. of Physics, Erevan). Prib. Tekh. Eksp.; No. 5, 17-20 (Sep-Oct 1969). (In Russian).

A method for measuring the instantaneous center of gravity of a beam in an accelerator chamber that does not require intensity normalization of the differential signal is proposed. The divergence of the beam is displayed to scale on a cathode ray tube. (tr-auth)

**15748** CONDENSERS FOR BENDING CHARGED PARTICLE BEAMS. Goldin, L. L.; Skachkov, S. V. (Inst. of Theoretical and Experimental Physics, Moscow). Prib. Tekh. Eksp.; No. 5, 20-4 (Sep-Oct 1969). (In Russian).

For bending charged-particle beams, condensers whose fields turn out to be homogeneous after averaging over the particle trajectories are used. The field of a condenser constructed for this purpose and placed in the vacuum chamber of an accelerator was studied. The electrodes of the condenser formed the surface of a cylinder with an oval cross section and were separated by a clearance gap. It was shown that in the region the distance of the clearance gap away from the electrodes the field is homogeneous within an accuracy of 4%. (tr-auth)

**15749** HIGH-FREQUENCY SOURCE OF NEGATIVE IONS. Gornitsyn, G. A.; Dyachkov, B. A.; Zinenko, V. I. Prib. Tekh. Eksp.; No. 5, 24-7 (Sep-Oct 1969). (In Russian).

The construction of an h-f source of negative ions is described. An ion current of $H_1^-$ of ~150 μA was obtained for a period of 500 hours. It was shown that the source can be used for obtaining negative ions of heavy elements. (tr-auth)

**15750** OIL VAPOR TARGET FOR THE TRANSFORMATION OF ATOMIC AND IONIC BEAMS. Sorokin, A. F. (Inst. of Nuclear Physics, Novosibirsk, USSR). Prib. Tekh. Eksp.; No. 5, 29-31 (Sep-Oct 1969). (In Russian).

The possibility of using a supersonic oil vapor jet as a target for the transformation of beams was studied. It was shown that the coefficient of charge exchange $I_0/I_+$ for $H^+$ and $H_2^+$ has the values 0.05–0.30 in the energy interval 300 eV–11 keV and 0.28–0.38 for $N^+$ in the energy interval 1.8–11 keV. The coefficient of ionization $I_+/I_0$ is changed from 0.02 to 0.12 for H atoms with energies 1.5–11 keV, from 0.064 to 0.12 for $H_2$ in the energy range 2.5–12 keV, and from 0.14 to 0.16 for N atoms of energies 3.2–11 keV. (tr-auth)

**15751** ROTATING TARGET FOR PRODUCING RADIOISOTOPES IN A CYCLOTRON. Konyakhin, N. A.; Krasnov, N. N.; Tuev, V. M. (Physico-Energetics Inst., Obninsk, USSR). Prib. Tekh. Eksp.; No. 5, 31-3 (Sep-Oct 1969). (In Russian).

Problems relative to the development of rotating targets for the production of radioisotopes in cyclotrons were examined. The construction of the target apparatus and targets for producing isotopes in industrial quantities was described. (tr-auth)

**15752** STATIONARY TARGETS FOR PRODUCING RADIOISOTOPES IN CYCLOTRONS. Konyakhin, N. A.; Krasnov, N. N.; Tuev, V. M. (Physico-Energetics Inst., Obninsk, USSR). Prib. Tekh. Eksp.; No. 5, 34-7 (Sep-Oct 1969). (In Russian).

Two types of stationary targets for internal and external beams of cyclotrons to be used for radioisotope production are described. The target element for the internal beam is an all-metal plate with bent edges (for example, Ta, Ag, Ti, etc.) or supported by coatings of such materials as Sb, Ge, La. The target element for the external beam is a cassette containing films of Ga, Rb, Sr, etc. Methods for producing these targets and irradiation techniques are briefly outlined. (tr-auth)

**15753** IMPOSSIBILITY OF CREATING DIVERGING ELECTRON-OPTICAL SYSTEMS ON THE BASIS OF TWO-DIMENSIONAL ELECTROSTATIC AND MAGNETOSTATIC FIELDS. Yakushev, E. M. (Alma-Ata Inst. of Nuclear Physics, USSR). Zh. Tekh. Fiz.; 39: 1934-40(Nov 1969). (In Russian).

Equations for relativistic charged-particle motion in arbitrary two-dimensional static fields were used to show that these fields exert a focusing effect on the moving charged-particle beams in the case in which electrical charges and currents, creating the external field, are absent in the region of the particle motion. The effect of the beam volume charge was not considered. The conclusions derived hold for particles with any velocities and are not limited by conditions of paraxial approximation. The motion of charged particles in certain simple electron-optical systems with two-dimensional electric and magnetic field is used as an illustrating example. (tr-auth)

**15754** STUDIES OF A SECTION OF A DISK-LOADED ELECTRON LINEAR ACCELERATOR. Kramskoi, G. D.; Grishaev, I. A.; Zykov, A. I.; Grizhko, V. M.; Biller, E. Z.; Ostrovskii, E. K.; Krondratenko, V. V. Zh. Tekh. Fiz.; 39: 2054-8(Nov 1969). (In Russian).

Tests were carried out on a section of a disk-loaded electron linear accelerator investigating the development of hybrid $EH_{11}$ type oscillations. It is shown that variation of the radial dimensions of the disks increases considerably the critical current in the section without affecting the electrical stability. (tr-auth)

**15755** STABILITY OF BETATRON OSCILLATIONS. Scarlat, F. (Inst. of Atomic Physics, Bucharest). Stud. Cercet. Fiz.; 21: 951-64(1969). (In Rumanian).

Topics include the stability of betatron oscillations in ideal magnetic systems, stability of betatron oscillations in nonideal magnetic systems, and the stability of betatron oscillations in cyclic particle accelerators. (auth)

**15756** STABILITY OF SYNCHROTRON OSCILLATIONS. Scarlat, F. (Inst. of Atomic Physics, Bucharest). Stud. Cercet. Fiz.; 21: 965-74(1969). (In Rumanian).

Phase trajectories of synchrotron oscillations are presented graphically, and the phase trajectory equation is presented as the integral of the synchrotron oscillation equation. Also, the equation for the synchrotron oscillation period is derived. (W.H.K.)

# PHYSICS (NUCLEAR)

## Neutron Interactions with Matter

*Refer also to abstracts 15728 and 15867.*

15757 (AD-687874) IMPURITY EFFECTS IN INTENSE PLASMA RADIATION SOURCES. Dazey, Mitchell H.; van Paassen, Hugo L. L.; Josephson, Vernal (Aerospace Corp., El Segundo, Calif.). Nov 1968. Contract F04701-68-C-0200. 17p. (TOR-200(4308)-1; SAMSO-TR-69-132). CFSTI.

The effect of the neutron yield of variations in electrode material in a paraboloidal deuterium plasma focus assembly was investigated. Beryllium, titanium, iron, copper, and palladium anode tips were tested. The most significant improvement in neutron yields was produced by elements that are good deuterium absorbers, such as titanium. Average neutron yields were increased by a factor of 20 when the copper anode tip was replaced by a titanium tip. (auth) (USGRDR)

15758 (KAPL-P-3860) IMPROVED THEORETICAL CROSS SECTION FOR POLYETHYLENE. Kirouac, G. J.; Jernow, S. K.; Moore, W. E.; Esch, L. J. (Knolls Atomic Power Lab., Schenectady, N. Y.). 18 Nov 1969. Contract W-31-109-eng-52. 9p. (CONF-691102-8). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

The low-energy neutron cross section for polyethylene was calculated using an improved method of orientation averaging. The polarization vectors of the vibrational modes were included rigorously in the treatment. The method works easily with existing codes. The calculations are in excellent agreement with experiment. (J.W.R.)

15759 (LA-4277) MAGNETIC RECORDING OF NEUTRON CROSS-SECTION DATA FROM AN UNDERGROUND NUCLEAR EXPLOSIVE SOURCE. Arlowe, H. D. (Sandia Labs., Albuquerque, N. Mex.); Furnish, A. P. (Los Alamos Scientific Lab., N. Mex.). 24 Sep 1969. Contracts W-7405-eng-36; AT(29-1)-789. 5p. Dep. CFSTI.

A small portion of the neutron cross-section data obtained from physics shot 8 (an event at the Nevada Test Site) was recorded in frequency modulation form on a rotating hard-surfaced magnetic disc. This is a novel way of recording these data. Magnetic recording allows electronic digitizing of the data, and thus eliminates the need for time-consuming film reading. (auth)

15760 (UCRL-Trans-10423) PRODUCTION AND STUDY OF POLARIZED MONOCHROMATIC SLOW NEUTRON BEAMS. Beil, H.; Carlos, P.; Matuszek, J. Translated by W. G. Robinson for Univ. of California, Lawrence Radiation Lab., Livermore, from J. Phys. (Paris); 24: 359-66(1963). 24p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 17: 41850.

15761 TWO-GROUP TRANSPORT THEORY IN PLANE GEOMETRY. Shieh, Paulinus Shee-shan. Raleigh, N. C.; North Carolina State Univ. (1969). 130p.

Thesis.

The two-group, time-independent, one-dimensional neutron transport equation with isotropic scattering is studied. Case's method is applied to prove the full-range completeness and orthogonality theorems and to find the infinite medium Green's function. The two-group half-space albedo problem is examined by using both the Case technique and the invariant imbedding method. In addition, the steady state polarized radiation distribution in a finite Rayleigh-scattering plane-parallel atmosphere due to an arbitrarily polarized parallel incident beam of radiation is obtained by utilizing Chandrasekhar's invariance principles and the normal-mode expansion technique. (Diss. Abstr.)

15762 TIME- AND ENERGY-DEPENDENT NEUTRON DISTRIBUTION IN A PULSED MULTIPLYING MEDIUM. Rodriguez, Pablo Jose. Austin, Tex.; Univ. of Texas (1969). 223p.

Thesis.

This investigation is an analysis of the transport operator's time eigenvalues for a multiplying medium which is subjected to a short burst of neutrons. The eigenvalues in both the discrete and continuous regions of the transport operator are determined. The first part of this analysis employs the Fourier method to reduce the one velocity integro-differential transport equation. In the second part, the multivelocity transport equation is examined in cylindrical coordinates. Both sections account for delayed neutrons. Spherical harmonics and Laplace transforms are used frequently to minimize the difficulties caused by the leakage term of the transport equation in cylindrical coordinates. The equation determining the eigenvalues in the first part of this analysis is expressed in two series expansions, one of which is shown to apply within the discrete region, and the other in the continuum and part of the discrete region. The effects of delayed neutrons on the fundamental eigenvalues were found to be small. Using the Minkowski' and Holder's inequalities it is shown that the upper bound of the discrete spectrum does exist and is indeed the fundamental decay constant. This result is summarized in a theorem. A detailed analysis is presented describing the contribution of the continuum region of the transport operator in a fissionable medium. The neutron spectrum was considered to be a Maxwellian distribution perturbed in energy by a small amount (Feynman's approximation). The medium chosen was assumed to have azimuthal symmetry. Several realistic cross sectional models were used in this analysis. For all these models it was found that the continuous region is represented by pure exponentials divided by a power of time. For subcritical and moderating media, the presence of the continuum is only important during the time immediately after the pulse is injected into the system. This contribution rapidly decays to zero and thus only the discrete contribution need be taken into account. It is observed for a supercritical system that the continuum increases with time in a rather slow manner as compared with its counterpart in the discrete region. Therefore the contribution of the continuous region is only a transient effect and can be neglected for long times. In the numerical calculations, a multigroup analysis is used and several codes were written to: (a) find the transport time eigenvalues, (b) take the inverse Laplace transform and (c) to determine the singularities in the complex plane. Of particular interest was the utilization of numerical techniques to take the inverse of the Laplace transform of the energy dependent neutron flux. This method yields results which are in good agreement with both experimental and theoretical results. (Diss. Abstr.)

15763 APPROXIMATE NUMERICAL SOLUTIONS TO TIME-DEPENDENT NEUTRON TRANSPORT EQUATIONS. Swanks, Jerry Haynes. Knoxville, Tenn.; Univ. of Tennessee (1969). 164p.

Thesis.

The purpose of this study was to develop an approximate solution to the time-dependent Boltzmann neutron-transport equation. The one-dimensional form of this equation is reduced to a set of discrete-ordinate equations in which the energy, angular, and space variables are treated as discrete variables; the time dependence is retained in its continuous form. The resulting set of equations is written in matrix form; and an integrating factor is defined. The simplifying assumption is made that the neutron flux behaves exponentially over a finite time interval, and the set of equations is integrated analytically. The introduction of the assumption of an exponential behavior results in the development of an iterative calculation algorithm which is used to determine the time-dependent behavior of the neutron flux. Under certain conditions, the resulting algorithm is shown to be numerically stable, and the asymptotic numerical solution is shown to be proportional to the asymptotic analytical solution. Results of calculations performed for several systems undergoing transients are presented and compared to solutions obtained by other methods. (Diss. Abstr.)

15764 SOLUTION OF THE ONE-VELOCITY TRANSPORT EQUATION IN TERMS OF SYNTHETIC KERNELS. Henryson II, Herbert. Berkeley, Calif.; Univ. of California (1968). 142p.

Thesis.

An approximate formalism is derived for solving problems in the one-velocity transport of neutrons in convex, isotropically scattering media. The integral transport equation is transformed to an equivalent infinite medium problem, to which the synthetic kernel method may be applied. It is then shown that the neutron flux may be approximated by the solution of a set of coupled diffusion type differential equations. These equations and their related boundary conditions are of the same form as the few-group diffusion equations so that solution may be obtained by use of existing multidimensional computer codes. Finally, the new formalism is applied to a number of simplified, though realistic problems and the results are compared with corresponding results provided either by rigorous treatment or by other approximate theories. In general, the accuracy of the formalism and the computational effect required are comparable with the simplified spherical harmonics method. In addition,

the flexibility available in choosing the parameters of the synthetic kernel offers the possibility of tailoring kernels to specific design problems. (Diss. Abstr.)

15765 THE USE OF KERNELS IN STUDYING NEUTRON TRANSPORT PROBLEMS. Cramer, Samuel Noel. Knoxville, Tenn.; Univ. of Tennessee (1968). 169p.

Thesis.

In the study of neutron transport in an air medium by the Monte Carlo technique, excessive computer time is required in following the neutrons through the keV and eV energy ranges due to the small energy loss per collision. At these energies, neutron scattering in air is elastic and isotropic in the center-of-mass system, the cross sections are slowly varying in energy, and absorptions are negligible. It is these conditions which make an analytic solution possible but cause a Monte Carlo solution to become time consuming. An analytic time-, spatial-, and energy-dependent kernel is derived for an infinite homogeneous medium with constant cross sections assuming continuous slowing down of neutrons. This kernel is coupled with a Monte Carlo solution creating an estimator from collisions in the keV energy range to lower energies. In addition to the analytic development, a general investigation of transport model coupling techniques is performed by solving the Boltzmann transport equation for two regions of phase space. It is shown that the coupling of the Monte Carlo and analytic models is a special case of the general coupling approach. Results from the analytic model and its combination with the Monte Carlo solution give excellent agreement with results from a complete Monte Carlo solution in the entire energy range. Considerable machine time is also saved in obtaining answers having comparable statistical error with the complete Monte Carlo solution. (Diss. Abstr.)

15766 PULSED NEUTRON RESEARCH. 3. Yamamuro, Nobuhiro; Arai, Eiichi (Tokyo Inst. of Tech.). Tokyo Kogyo Daigaku Gakuho; No. 90, 139-49(Mar 1969).

This report briefly shows some features of the pulsed neutron research. Neutron burst with a very short half-width, of the order of 10–50 nsec, was obtained by chopping the deuteron beam accelerated for the neutron pulse generation. The accelerator consists of (1) a high frequency ion source, (2) a pulsing chamber with a lens system and a grid pulser for microsecond pulse, (3) an acceleration tube and (4) a beam transport system which serves to switch and guide the accelerated deuteron beam to the target. Instead of the previously used 25 MHz oscillator, a 125 MHz oscillator was used for the r. f. ion source to obtain larger extracted and unmodulated current. Pulsed neutron experiments on assemblies of natural uranium or lead are being carried on. A typical experimental result and its analysis are shown. Measurements of neutron spectra by time-of-flight method in pure water, boron-poisoned water and gadolinium-poisoned water were performed using the new accelerator. (NSA of Japan)

15767 THERMAL FLUX DISTRIBUTION WITH TEMPERATURE-DISCONTINUITY. Jain, V. K. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 342-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The problem of thermal flux distribution in an infinite slab with a temperature discontinuity is studied using the two-thermal-group method. Results are presented for several different mass numbers and temperature discontinuities. (J.W.R.)

15768 PULSED NEUTRON TECHNIQUE APPLIED TO HETEROGENEOUS MEDIA. Deniz, V. C. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 351-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The application of pulsed neutron techniques in the evaluation of total leakage probability was studied both experimentally and theoretically. Experiments were performed on graphite lattices with the channels being either empty or containing fissile and non-fissile material. (J.W.R.)

15769 CALCULATION OF THE AGE OF NEUTRONS FROM A PLANE SOURCE IN AN INFINITE HOMOGENEOUS MEDIUM. Balakrishnan, Kamala (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 365-8(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

A code for the calculation of the age of neutrons emitted from a plane source in an infinite homogeneous medium is described. The necessary input data are listed. A sample calculation for neutron age in water is compared with experimental data. (J.W.R.)

15770 SYMMETRIES IN SCATTERING OF SLOW NEUTRONS. Kuscer, I. (Cornell Univ., Ithaca, N. Y.); Summerfield, G. C. Phys. Rev.; 188: 1445-9(15 Dec 1969).

Reciprocity, detailed balance, and other symmetry laws for slow-neutron scattering are discussed for the case of anisotropic media. While Friedel's law, stating that $\Sigma(\nu \rightarrow \nu') = \Sigma(-\nu \rightarrow -\nu')$, may fail for polar absorbing media, reciprocity as a consequence of time-reversal invariance, and of thermal equilibrium of the medium, remains valid. The optical theorem helps to derive a reciprocity relation for the total cross section $\Sigma(\nu) = \Sigma(-\nu)$. Similar conclusions are derived for the matrices used to describe scattering of polarized neutrons. The two reciprocity relations lead to a macroscopic reciprocity theorem, expressing a symmetry property of Green's functions of the linearized Boltzmann equation. (auth)

15771 PULSED NEUTRON SOURCE FOR REACTOR PHYSICS. Szabo, Z. (Central Research Inst. for Physics, Budapest). Nucl. Instrum. Methods; 78: 199-205(1970).

A 200 keV D-T neutron source with an orientable accelerating tube is described. The extraction system of the rf ion source, the choice of the pulsation method, the light transmission triggering device of the oscillator and the insulating core transformer serving as E.H.T. supply are discussed in detail. The neutron yield during the pulse is $\approx 10^{11}$ n/sec, pulse lengths range from 10 μsec to 1 msec, repetition rates from 0.1 to 2000 pps, the maximum duty ratio is 1:50. (auth)

15772 INTERFERENCE EFFECTS IN SLOW NEUTRON PENETRATION THROUGH LIQUID LEAD AND SODIUM. Khrushchev, B. I.; Sharipova, L. S. At. Energ. (USSR); 27: 511-15(Dec 1969). (In Russian).

The total slow neutron scattering cross-section measurements were performed on sodium and lead, with wave lengths λ from 3.3 to 7.6 Å. In the case of sodium $\sigma_t(\lambda)$ was measured at room temperature, at 90, 100, 300, 500, 700°C, and at boiling temperature. In the case of lead—at room temperature, at 320, 330, 550, 830, 1000, 1200, and 1400°C. The complex form the curve $\sigma_t(\lambda)$ and a presence of several maxima in the case of liquid lead indicate that there exist structural formations similar to that of crystal. Comparison between positions of maxima for a number of lattices and maxima of the curve $\sigma_t(\lambda)$ and cross sections calculated with the help of the quasicrystalline model as well as analysis of the temperature dependence of $\sigma_t(\lambda)$ make it possible to conclude that in liquid lead there are two modifications with two different structures of near order. These modifications—F. C. C. and B. C. C.—exist at the same time up to 830°C. The contribution of the B. C. C. modification increases up to 80% with increase of the temperature. In liquid sodium one observes a correspondence of structures in two phases near the melting point. At high temperatures, both in sodium and lead cases, the form of $\sigma_t(\lambda)$ becomes similar to that of $\sigma_t(\lambda)$ for liquefied gases near the boiling point. In the sodium case only, at the boiling point, the form of $\sigma_t(\lambda)$ becomes similar to that of a gas system. (auth)

## Nuclear Properties and Reactions, A≤ 5

*Refer also to abstracts 15474, 15609, 15813, 15814, 15987, and 15999.*

15773 (LA–4334) POLARIZATION MEASUREMENTS OF 16.5-MeV AND 22.1-MeV NEUTRONS ELASTICALLY SCATTERED FROM LIQUID TRITIUM AND LIQUID DEUTERIUM. Walter, Roger Kenneth (Los Alamos Scientific Lab., N. Mex.). 10 Nov 1969. Contract W-7405-eng-36. 181p. Dep. CFSTI.

Thesis.

Cryogenic scattering samples of approximately one mole of liquid tritium and liquid deuterium were used in the measurement of $T(\vec{n},\vec{n})T$ and $D(\vec{n},\vec{n})D$ scattering. The source of 16.5-MeV, −54% polarized neutrons and of 22.1-MeV, +40% polarized neutrons was the $T(\vec{d},\vec{n})^4He$ reaction with an incident deuteron energy of 6.0 MeV. The left-right scattering asymmetries for laboratory angles from 40° to 118.5° were measured with a two-detector, time-of-flight spectrometer; and after neutron-gamma-ray discrimination was applied, the pulse height spectra were routed to an on-line computer for preliminary data analysis. The measured asymmetry for $T(\vec{n},\vec{n})T$ at $E_n = 22.1$ MeV is negative at angles forward of 95° (lab) and positive at larger angles. The extrema of the n-T polarizations are −60% at 85° (lab) and +98% at 110° (lab). $T(\vec{n},\vec{n})T$ polarizations for $E_n = 16.5$ MeV are negative at forward angles.

D($\vec{n}$,$\vec{n}$)D polarizations at $E_n$ = 22.1 MeV are measured to be small and negative at forward angles and small and positive at back angles. (auth)

**15774** STUDY OF PICK-UP REACTIONS BY THE NUCLEI $^4$He, $^6$Li, AND $^7$Li AT 156 MeV AND FINAL STATE INTERACTIONS. Bernas, Monique (Laboratoire Joliot-Curie de Physique Nucleaire, Orsay, France). Ann. Phys. (Paris), 3: 213-58 (July–Aug 1968). (In French).

Thesis.

A series of experimental investigations on pick-up reactions was carried out with a 156-MeV proton beam, on the nuclei of mass A ≤ 16. In particular pick-ups were made on $^6$Li and $^7$Li nuclei to prove the feasibility of neutron capture from the inner nuclear 1s shell and to obtain the spectroscopic data of 1p shell pick-ups. Subsequently the nucleus $^4$He was examined and the complete angular distribution of the particles of the reaction $^4$He + p → d + $^3$He obtained. Finally double pick-ups (p,t) and (p,$^3$He) were produced in order to study the interaction of the two residual nuclei. The kinematics of the pick-up reaction are explained by the Watson approximation formula which is perfectly applicable to the obtained data. Experimental results and theoretical calculation are in good agreement. (F.J.W.)

**15775** DEUTERON BREAKUP BY PROTONS AT 100 MeV. Pan, Ellen Pi-jung. Montreal; McGill Univ. (1968).

Thesis.

Inelastic scattering of protons by deuterons was investigated at 100 MeV incident proton energy. Experiments were carried out by the technique of detecting the two outgoing protons in coincidence, and energy data were collected with a two-parameter pulse-height analyzer. Attention was paid to those angular configurations of detectors where the mean energies of the undetected neutrons were small, and where final state interactions between two of the three final-state nucleons were expected. The spectator model is able to reproduce the shape and describe qualitatively those spectra which correspond to small mean neutron energies. For those spectra in which peaks due to the formation of the virtual (singlet) deuteron state were observed, predictions based on the use of the generalized density-of-states function were less successful. (Diss. Abstr.)

**15776** EXPERIMENTAL STUDIES OF SPIN DEPENDENCE IN p,$^3$He ELASTIC SCATTERING. McSherry, Diana Hartridge. Houston, Tex.; Rice Univ. (1969). 125p.

Thesis.

Spin-dependent phenomena, including $^3$He recoil polarization and spin correlation effects, have been studied for p, $^3$He elastic scattering in the 4 to 11 MeV energy range. Data were taken at four angles using a $^3$He target polarized by the technique of optical pumping and an unpolarized proton beam. The spin correlation effects were measured at two angles at 8.8 MeV using both polarized beam and polarized target. A phase shift analysis, including cross section, proton polarization, $^3$He polarization, and spin correlation data, has been done for five energies from 4.0 to 10.7 MeV. In addition, the solution space for various phase shifts and mixing parameters has been studied in detail, including consideration of possible correlations between scattering parameters. (Diss. Abstr.)

**15777** POLARIZATION IN PROTON–HELIUM SCATTERING AT 70 AND 80 MeV. Stetz, Albert William. Berkeley, Calif.; Univ. of California (1968). 83p.

Thesis.

A helium-filled streamer chamber was used to observe the scattering of protons in gaseous helium. With an image intensifier and special high-voltage equipment, consistently good photographs over many hours of operation were obtained. The system made possible good resolution, in the projection mode, of tracks which differed greatly in ionization density. Since the gas in the streamer chamber was used as the scattering target, vertices involving very low-energy particles were obtained. The recoil proton polarization in p + He$^4$ elastic scattering was measured at 70 and 80 MeV incident proton energy. With this data, as well as that at 96 MeV and lower energies, the polarization at forward angles is essentially determined from zero to 96 MeV. The forward polarization peak, which increases with increasing energy above 70 MeV, makes helium an attractive analyzer for polarized nucleons at these energies. Phase shift analyses of the 63.3, 70, 80 and 96 MeV data obtained solutions which vary smoothly with energy and are consistent with results at lower energies. (Disser. Abstr.)

**15778** THE REACTION d + d → p + t AND ELASTIC DEUTERON-DEUTERON SCATTERING AT 51.5 MeV. Brueckmann, H.; Haase, E. L.; Kluge, W.; Schaenzler, L. (Univ., Karlsruhe, Ger. Kernforschungszentrums, Karlsruhe, Ger.). Z. Phys., 230: 383-90(1970).

The elastic deuteron-deuteron scattering and the reactions d(d,p)t and d(d,$^3$He)n were investigated at an incident deuteron energy of 51.5 MeV. The time-of-flight technique was used for the particle identification. The observed angular distributions for the (d,p) and (d,n) reaction are identical within the accuracy of the experimental data. The experimental results for the reaction d(d,p)t are compared with a theoretical prediction based on the application of a generalized separable potential model to the four nucleon systems. Information on the single deuteron break-up reaction d + d → d + p + n and on the double deuteron break-up reaction d + d → p + p + n + n is contained in the observed continuous proton and deuteron spectra. The double break-up seems to contribute only a rather small amount to the whole break-up cross section. (auth)

**15779** HARTREE–FOCK CHARGE DISTRIBUTION AND THE FORM FACTOR OF $^4$He. Kaushal, R. S.; Waghmare, Y. R. (Indian Inst. of Tech., Kanpur). Nuovo Cim., Lett.; 2: 639-42(11 Nov 1969).

The charge density of $^4$He was calculated by the Hartree-Fock method. This was then used to calculate the electron-scattering form factor. The form factor was compared with recent experimental results and other calculations. Argument with experiment was excellent for $q^2 < 10$ fm$^{-2}$, but it was poor for large $q^2$. (J.W.R.)

**15780** APPROXIMATE WAVE FUNCTIONS IN NUCLEAR TWO-BODY PROBLEMS. Kirwan, Donald Frazier. Columbia, Mo.; Univ. of Missouri (1969). 130p.

Thesis.

Calculations are made of nuclear two-body problems, testing approximate ground state wave function expansions in spherical harmonic oscillator (ho) eigenfunctions. Attractive central square well potentials are assumed together with infinite hard cores, square soft cores and no core repulsions. The expansions converge most slowly to a minimum energy for square soft cores, requiring one nonlinear and 23 linear parameters to reach 97% of the deuteron binding energy. In two tightly bound models simulating three- and four-body systems, equivalent accuracy is obtained with less than half as many parameters. With inclusion of a square well tensor interaction, one nonlinear and 23 linear parameters give 75% of the deuteron binding energy. Exact and approximate form factors and radii are compared. The feasibility of extending the present method to a triton calculation is discussed. E1 photodisintegration cross sections ($\sigma_{E1}$) for soft-core central deuteron and tight-binding models are calculated. The equivalence of $\underline{E}\cdot\underline{r}$ and $\underline{A}\cdot\underline{p}$ (with exchange), known to be true when exact wave functions are used, is tested with the ho expansions. Even with the most accurate trial functions, large shifts of the approximate deuteron $\sigma_{E1}$ peaks are found. In locating the peak and height of $\sigma_{E1}$, exchange currents are significant and become dominant for tight bindings. (Diss. Abstr. Int., B)

**15781** THREE-BODY PROBLEM WITH TWO CHARGED PARTICLES. Adya, Shrikant Rangacharya. Philadelphia, Univ. of Pennsylvania (1968). 78p.

Thesis.

A system of three particles, of which two are charged, is considered. The nuclear potential between any pair of particles is taken to be of the separable form. In particular, a simple s-wave Yamaguchi type of nuclear interaction is chosen. Spin, tensor forces and hard core effects are neglected. The Faddeev formalism is applied to study: (A) A model $^3$He system, and (B) A model for elastic p-d scattering. The primary interest lies in seeing how the Coulomb Potential between the two charged particles can be incorporated into the framework of the Faddeev formalism with separable nuclear interactions. To this end, use is made of an approximate form for the Coulomb wave function in momentum space, together with the resulting Coulomb Green's function. For the $^3$He system, an improved version of the approximation is also used. This improved version depends on the particular Yamaguchi nuclear interaction chosen. Using the two approximations for the Coulomb Green's function, the binding energy of the model $^3$He system is calculated in each case. The results are then compared with a first order perturbation calculation. The second (improved) version of the approximation gives a reasonably satisfactory result, but not the first. For the scattering problem the first version alone is used. The total amplitude for the elastic "p–d" scattering is shown to be the sum of a Coulomb-modified nuclear term and a nuclear-modified Coulomb term. For the nuclear part, Faddeev type equations are set up and the equations are inverted numerically on a high-speed electronic computer. For computational purposes it becomes necessary to make approximations in addition to those used for the Coulomb wave function and the Coulomb Green's function. The differential scattering cross section for elastic "p–d" scattering is calculated. The calculations are re-

peated with the Coulomb potential "switched off" and the results are compared with the Coulomb scattering. (Diss. Abstr. Int., B)

**15782** HYPOTHESIS OF PARTIALLY CONSERVED AXIAL-VECTOR CURRENT AND MESON-EXCHANGE EFFECTS IN $p + p \rightarrow d + \pi^+$ AND $^3H \rightarrow {}^3He + e^- + \bar{\nu}_e$. Cheng, W. K. (Stevens Inst. of Tech., Hoboken, N. J.); Fischbach, Ephraim. Contract AT(30-1)-3668B. Phys. Rev.; 188: 1530-9(20 Dec 1969).

The hypothesis of partially conserved axial-vector current (PCAC) is applied to relate the threshold production amplitude for the process $\alpha \rightarrow \beta + \pi^+$ to the meson-exchange contributions in $\alpha \rightarrow \beta + e^- + \bar{\nu}_e$, where $\alpha$ and $\beta$ are nuclear states. The latter contributions are calculated by assuming that the two-nucleon $\beta$-decay process $N_i + N_j \rightarrow N_f' + N_f'' + e^- + \bar{\nu}_e$ is dominated by the one-pion-exchange contribution. Particular attention is given to the radial dependence of the effective two-body operator which is used to describe both $p + p \rightarrow d + \pi^+$ and the meson-exchange effects in $^3H \rightarrow {}^3He + e^- + \bar{\nu}_e$. It is shown that terms as singular as $x^{-2}e^{-x}$ and $x^{-3}e^{-x}$ can arise naturally in a dynamical (as opposed to a phenomenological) treatment of meson-exchange effects, and that these terms contribute significantly to $p + p \rightarrow d + \pi^+$ but not at all to $^3H \rightarrow {}^3He + e^- + \bar{\nu}_e$. Some discussion of the present experimental status of these two processes is also given. (auth)

**15783** PROTON–NEUTRON FINAL-STATE INTERACTION. Boyd, D. P. (Rutgers–The State Univ., New Brunswick, N. J.); Donovan, P. F.; Mollenauer, J. F. Phys. Rev.; 188: 1544-67 (20 Dec 1969).

The reactions p(d,2p)n and d(p,2p)n were studied at a proton bombarding energy of 16.0 MeV and deuteron bombarding energies of 16.0 and 10.0 MeV. The protons were detected in coincidence with solid-state detectors at angles that allow strong enhancement of the p-n final-state interaction. The coincidence resolving time was sharpened by using time-energy correlation techniques that utilize an on-line SDS-910 computer. The data were analyzed using the "data-simulation technique." A simple theory, which, apart from normalization, contained three adjustable parameters, was found to produce satisfactory fits. In this theory, the final-state interactions are accounted for by assuming additive enhancements for each pair of final-state particles and each spin state. The primary interaction is approximated by the sum of a constant amplitude plus the spectator-effect amplitude. The widths of the final-state interaction peaks are in good agreement with Watson theory using the known singlet p-n scattering length $a_{np^s}$ of −23.69 F. The most accurately determined scattering length was extracted from the 16-MeV p + d data and was $a_{np^s} = -23.8 \pm 0.5$ F. This agreement indicates that interference effects are not important in this reaction at center-of-mass energies above a few MeV if coincidence techniques are employed. With similar methods, a comparative study of the n + d reaction in order to measure the singlet n-n scattering length should be fruitful. (auth)

**15784** EFFECT OF ΛN TENSOR FORCE ON $^5_\Lambda$He. Law, J.; Gunye, M. R.; Bhaduri, R. K. (McMaster Univ., Hamilton, Ont.). Phys. Rev.; 188: 1603-11(20 Dec 1969).

The effect of a tensor component in the ΛN force on the binding $B_\Lambda$ of a Λ particle in $^5_\Lambda$He is investigated using the Hartree–Fock and rigid-α models. Second-order effects of the ΛN tensor force are taken into account in an approximate way. With a variety of ΛN noncentral forces that fit the low-energy Λp scattering data, overbinding of $^5_\Lambda$He persists. For $B_\Lambda$ calculations in this hypernucleus, the rigid-α model is found to be as good as the more elaborate Hartree–Fock scheme. (auth)

**15785** QUASIFREE p–n SCATTERING IN DEUTERON BREAK-UP INDUCED BY 46-MeV PROTONS. Petersen, E. L. (San Fernando Valley State Coll., Northridge, Calif.); Bondelid, R.; Tomas, P.; Paic, G.; Richardson, J. Reginald; Verba, J. W. Phys. Rev.; 188: 1497-1509(20 Dec 1969).

The disintegration of deuterons by protons was investigated in a kinematically complete experiment detecting neutrons and protons. Measurements were made at 42 different pairs of angles, in and out of the scattering plane, using an associated charged-particle time-of-flight technique and a proton counter telescope. Experimental results are compared with spectator-model calculations, using the impulse approximation, and a Chew–Low extrapolation is presented. At a few sets of angles the n-p final-state interaction was observed. (auth)

**15786** (p,2p) REACTIONS AT 600 MeV ON DEUTERIUM AND $^4$He. Perdrisat, C. F. (Coll. of William and Mary, Williamsburg, Va.); Swenson, L. W.; Gugelot, P. C.; Boschitz, E. T.; Roberts, W. K.; Vincent, J. S.; Priest, J. R. Phys. Rev.; 187: 1201-9(20 Nov 1969).

The differential cross section $(d\sigma/dE d\Omega^2)$ for (p,2p) reactions induced by 600-MeV protons on deuterium and $^4$He was studied for symmetric reaction kinematics. By varying the detection angles of the two outgoing protons, the D(p,2p)n reaction was investigated for recoil momenta of the residual nucleus between 180 MeV/c antiparallel and 370 MeV/c parallel to the incident proton direction, respectively. For the $^4$He(p,2p)$^3$He reaction, the corresponding numbers are 148 and 298 MeV/c, respectively. Some data for asymmetric reactions in $^4$He are also presented. Analyzing the data in terms of the plane-wave-impulse approximation, the single-proton momentum distribution in both nuclei was calculated. For deuterium, a sudden change of slope in the momentum distribution around 150 MeV/c was observed, which cannot be explained with theoretical momentum distributions obtained by Fourier transforming Hulthén or Hamada-Johnston deuteron wave functions. In $^4$He, the momentum distribution is nearly Gaussian up to about 180 MeV/c; above this value, an excess of large momentum components is observed. Both the deuterium and $^4$He results seem to indicate that the plane-wave impulse approximation is not valid at this energy and for the reaction parameters investigated here. Multiple scattering effects might be at the origin of the apparent excess of large Fermi momentum components obtained when the data are analyzed with the impulse approximation. (auth)

**15787** USE OF PHOTONUCLEAR SUM RULES IN THE STUDY OF LIGHT NUCLEI. Erdas, F.; Mosconi, B.; Pompei, A.; Quarati, P. (Univ., Cagliari, Italy. Univ. of Glasgow). Nuovo Cim.; 64B: 406-18(11 Dec 1969).

The method of multipole sum rules is applied to the photodisintegration of $^3$He, $^4$He, $^{12}$C, $^{14}$N, $^{16}$O. A comparison is made with the classical Levinger-Bethe and Migdal sum rules, and the total E2 photoabsorption is calculated. (auth)

**15788** MEASUREMENT OF THE SPIN CORRELATION PARAMETERS $A_{xx}$ AND $A_{yy}$ FOR PROTON–PROTON SCATTERING AT 47.5 MeV. Nisimura, K. (Kyoto Univ.); Hasegawa, T.; Saito, T.; Takasaki, E.; Horikawa, N.; Nakanishi, T.; Saito, M.; Sugimoto, S.; Yamaki, T.; Ueno, H. Phys. Lett.; 30B: 512-13 (22 Dec 1969).

A measurement of the spin correlation parameters $A_{xx}(90^\circ_{cm})$ and $A_{yy}(90^\circ_{cm})$ of 47.5 MeV proton–proton scattering was performed by means of a polarized beam and a polarized target. (auth)

**15789** OFF-SHELL EFFECTS IN THE THREE-NUCLEON PROBLEM. Fiedeldey, H. (Atomic Energy Board, Pelindaba, S. Afr.). Phys. Lett.; 30B: 603-6(22 Dec 1969).

Using a previously reported solution of the inverse scattering problem for rank two separable potentials, off-shell effects on the binding energy of the model triton are investigated. Much larger effects are found than previously reported in the literature. (auth)

**15790** POLARIZATION OF 22 MeV NEUTRONS ELASTICALLY SCATTERED FROM LIQUID TRITIUM. Walter, R. K.; Hopkins, J. C.; Kerr, E. C.; Martin, J. T.; Niiler, A.; Seagrave, J. D.; Sherman, R. H.; Dixon, D. R. (Los Alamos Scientific Lab., N. Mex.). Phys. Lett.; 30B: 626-7(22 Dec 1969).

The asymmetries from $T(\vec{n},\vec{n})T$ elastic scattering of 22.1 MeV incident neutrons was measured for 11 laboratory angles between 40° and 118.5°. The extrema are −60% at 85° (lab) and +98% at 110° (lab). (auth)

## Nuclear Properties and Reactions, 6 ≤ A ≤ 19

*Refer also to abstracts 13782, 15450, 15474, 15475, 15496, 15774, 15787, 15953, 15957, 15979, 15981, 15989, 15994, and 15999.*

**15791** (JINR-P2-4808) HIGH-ENERGY INTERACTIONS OF γ-QUANTA WITH NUCLEI. Gudima, K. K.; Il'inov, A. S.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1969. 10p. Dep. CFSTI (U.S. Sales Only). (In Russian)

The calculation results are presented for the photo-nuclear reactions at high energies obtained by means of cascade model suggested previously. A good agreement of theory and experiment on the total characteristics both for light and heavy nuclei is noted. (auth)

**15792** (UARAEE-5-A). EXCITATION FUNCTION AND ANGULAR DISTRIBUTION OF THE REACTION $^6$Li(d,α)$^4$He. Antoufiev, Y. F.; El-Sheshini, M. M.; Saad, H. R.; Saleh, Z. A.; Sorokin, P. V. (Atomic Energy Establishment, Cairo (Egypt). Nuclear Physics Dept.). Jan 1963. 30p. Dep. CFSTI (U. S. Sales Only).

The excitation function for $^6$Li(d,α)$^4$He reaction was measured over the deuteron energy range 1 to 2.5 MeV. No sharp reso-

nance appeared in this energy range but only the tail of a resonance at energy 0.75 MeV. Angular distributions were measured at energies 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, and 2.5 MeV in the backward direction. The experimental results were fitted with theoretical angular distributions by assuming the reaction in this energy interval as a direct nuclear interaction in which the $^6$Li nucleus was considered to be as an $\alpha$ particle plus a deuteron. The incident deuteron picks up the deuteron in the $^6$Li nucleus, and the two $\alpha$-particles are emitted in opposite directions. The experimental results are in agreement with the theoretical calculations. (auth)

15793 A STUDY OF THE SECOND EXCITED STATE OF $^8$Be BY THE $^{10}$B(d,$\alpha_2$)$^8$Be REACTION. Strauss, L.; Friedland, E. (Univ. of Pretoria). Z. Phys.; 230: 309-16(1970).

The second excited state of $^8$Be was studied by analysis of the coincidence spectra of the reaction $^{10}$B(d,$\alpha$)2$\alpha$ for $E_d$ = 1.0 to 2.0 MeV. The excitation energy was found to be 12.0 ± 0.4 MeV, and the reduced width 0.85 ± 0.12 MeV. Differential cross sections of the (d,$\alpha_2$)-reaction were deduced. (auth)

15794 THE ($\alpha$,d) REACTION ON LIGHT- AND MEDIUM-MASS NUCLIDES. Lu, Chi Chang. Berkeley, Calif.; Univ. of California (1968). 140p.

Thesis.

The ($\alpha$,d) reactions on targets of $^{13}$C, $^{14}$C, $^{15}$N, and $^{20}$Ne were studied using alpha particle beams of 40.1, 46.0, 45.4, and 44.5 MeV, respectively. Angular distributions were obtained. States with $(1d_{\frac{5}{2}})^2_{T=0}$ configuration were located and possible spin assignments were suggested. These states are: $^{15}$N 13.03 MeV ($11/2^-$), 11.95 MeV ($9/2^-$); $^{16}$N 5.75 MeV (5+); $^{17}$O 7.74 MeV ($11/2^-$), 9.14 MeV ($9/2^-$); $^{22}$Na 1.528 MeV (5+). Separated isotopes of $^{52}$Cr, $^{54,56}$Fe, $^{59}$Co, $^{58,60,62}$Ni, $^{63}$Cu, and $^{64,66,68}$Zn were used as targets to study the ($\alpha$,d) reaction with a 50-MeV alpha particle beam. States with a probable configuration of $(1g_{\frac{9}{2}})^2_{T=0}$ were located. These states are $^{54}$Mn 9.47 MeV, $^{58}$Co 8.92 MeV, $^{58}$Co 6.79 MeV, $^{66}$Cu 5.99 MeV, $^{62}$Cu 4.75 MeV, $^{64}$Cu 4.57 MeV, $^{66}$Ga 2.99 MeV, $^{68}$Ga 2.88 MeV, $^{70}$Ga 2.88 MeV. The residual interaction energies between the proton and neutron in the configurations $(1d_{\frac{5}{2}})^2_{T=0}$ and $(1f_{\frac{7}{2}})^2_{T=0}$, and $(1g_{\frac{9}{2}})^2_{T=0}$ were extracted from the excitation energies determined in the present work and previous work on $(1d_{\frac{5}{2}})^2_{T=0}$ and $(1f_{\frac{7}{2}})^2_{T=0}$ states. For $T_z \neq 0$ nuclides, an "interaction model" method was proposed to extract the residual interaction energy. The mean values of the residual interaction energies are about -3.9, -3.0, -2.2 MeV respectively for the three mentioned configurations. There is a slight decrease of residual interaction energy with increasing A. These results are reproduced excellently by conventional shell model calculations. The results of ($\alpha$,t) reactions studied simultaneously with the ($\alpha$,d) reactions are also briefly reported. (Diss. Abstr.)

15795 AN EXPERIMENTAL INVESTIGATION OF THE PARITY PURITY OF THE 110-keV GAMMA DECAY OF $^{19}$F. Moline, Robert Alan. Pasadena, Calif.; California Inst. of Tech. (1969). 100p.

Thesis.

If either, or both, of the ground state ($J^\pi = 1/2^+$) and first excited state (110 keV, $J^\pi = 1/2^-$) of the $^{19}$F nucleus have impure parity, it follows that the de-excitation $\gamma$ rays would have an angular distribution of the form, $W(\theta) = 1 + P\eta \cos(\theta)$. By assuming the existence of a parity-violating, weak-interaction, nucleon–nucleon force, Maqueda has predicted that the asymmetry parameter, $|\eta|$ in the above expression, should be $4.3 \times 10^{-4}$. Coulomb excitation of 37.5-MeV $^{19}$F projectiles in a gold target was used to produce $^{19}$F* (110 keV) nuclei with a large polarization perpendicular to the scattering plane. From the asymmetry observed in the $\gamma$-ray counting rate, the quantity $P\eta$ was determined to be $(6.6 \pm 5.9) \times 10^{-4}$. Since the magnitude (and sign) of P is dependent on the hyperfine magnetic field, investigations were carried out to determine the average hyperfine field of fluorine in iron by using the nuclear reaction $^{16}$O($^3$He,p)$^{18}$F* (937 keV). A p-$\gamma$ coincidence technique was used, and the average precession angle of the excited nuclei during their mean life of (68 ± 7) ps was observed, when the $^{18}$F* recoiled into an iron host lattice. The results indicate an average hyperfine field of (88 ± 19) kG for fluorine in iron, if the g-factor of the 937-keV state is assumed to have the theoretical value 0.61. If it is assumed that the 110-keV level of $^{19}$F has a g-factor of –0.57 and a mean life of 0.88 ns, the most probable value for the net polarization is 0.109 ± 0.023, resulting in an asymmetry coefficient, $\eta$, of $(6.1 \pm 5.6) \times 10^{-4}$. (Diss. Abstr.)

15796 PURITY OF SHELL-MODEL FUNCTIONS AND THE DECAY OF $^9$Be* (2.43 MeV). Bouten, M. (SCK–CEN, Mol, Belgium). Physica; 44: 617-20(3 Nov 1969).

The amount of excited configurations in nuclear wave functions is considered in the Hartree–Fock approximation. It is further shown that the f-wave nucleon decay of $^9$Be* (2.43 MeV) is difficult to interpret as a measure for the f-state admixture, due to the uncertainty in the degree of intermediate coupling. (auth)

15797 THE EXCITATION OF UNNATURAL-PARITY STATES IN $^{24}$Mg, $^{20}$Ne, AND $^{16}$O BY INELASTIC $\alpha$ SCATTERING. Reed II, Mary Frances. Berkeley, Calif.; Univ. of California (1968). 134p.

Thesis.

The excitation of unnatural-parity states ($\pi \neq (-)^J$) in even–even nuclei was studied by inelastic $\alpha$ scattering over the energy range of 33 to 120 MeV. Data are reported for the low-lying states in three nuclei—$^{24}$Mg, $^{20}$Ne and $^{16}$O. The excitation of unnatural-parity states is forbidden in simple, one-step, direct reaction theories by spin and parity considerations. Since these states are excited with moderately large cross sections, the study of them sheds light on more complicated reaction mechanisms. When the angular distributions for these reactions at the various energies are compared with each other, consistent results are obtained for the natural-parity states and for the $2^-$ state in $^{16}$O. However, for the $2^-$ state in $^{20}$Ne and the $3^+$ state in $^{24}$Mg, unusual angular distributions are obtained which bear no resemblance to the theories. Calculations of compound nucleus and multiple excitation cross sections are made using Hauser–Feshbach and coupled-channel computer codes. The multiple excitation cross sections produced in this way give fairly good agreement with the experimental data, even reproducing the unusual appearance of the $3^+$ angular distributions. Thus the excitation of the unnatural parity state in $^{24}$Mg is determined to be mainly a multiple-step process. (Diss. Abstr.)

15798 ABSOLUTE DIFFERENTIAL CROSS-SECTION FOR THE REACTION $^6$Li($\alpha$,$\alpha$)$^6$Li BETWEEN 3.30 AND 5.00 MeV AND SHAPE ANALYSIS OF THE RESONANCE AT 4.25 MeV. Balakrishnan, M.; Sekharan, K. K.; Mehta, M. K.; Divatia, A. S. (Bhabha Atomic Research Center, Trombay, India). Proc. Nucl. Solid State Phys. Symp., Bombay, 1968; 2: 44-50 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-68210(Vol.2).

Alpha elastic scattering by $^6$Li was studied at 3.3 to 5.0 MeV. Absolute differential cross sections were measured in 5-keV steps at the laboratory angles of 43, 56, 84, and 100°. A shape analysis was performed for the anomaly at 4.25 MeV. This resonance corresponds to the 7.913-MeV level of $^{10}$B. A spin-parity assignment of $2^+$ was made for the resonance. (J.W.R.)

15799 ELASTIC ELECTRON SCATTERING EXPERIMENTS WITH $^{15}$N. Dally, E. B. (Stanford Univ., Calif.); Croissiaux, M. G.; Schweitz, B. Contract Nonr 225 (67). Phys. Rev.; 188: 1590-4(20 Dec 1969).

The nucleus of $^{15}$N has been investigated by the electron scattering technique at incident energies of 250 and 400 MeV. The first diffraction minimum has been observed and measured. The data have been analyzed by using two nuclear charge density distributions: the Fermi model and the shell model. A phase-shift program was used for the analysis. A value for the radius and skin thickness of the $^{15}$N nucleus is given, although the data do not fit the diffraction minimum. For the Fermi model, the rms radius is 2.7 F; the shell model yields 2.6 F. (auth)

15800 POLARIZATION AND DIFFERENTIAL CROSS SECTION FOR NEUTRONS SCATTERED FROM $^{12}$C. Lane, R. O. (Ohio Univ., Athens. Argonne National Lab., Ill.); Koshel, R. D.; Monahan, J. E. Phys. Rev.; 188: 1618-25(20 Dec 1969).

The polarization $P(\theta)$ and differential cross section $\sigma(\theta)$ for the scattering of neutrons of $0.1 \leq E_n \leq 2.0$ MeV from $^{12}$C have been measured at five or nine angles. $P(\theta)$ contains a slowly varying sin $\theta$ term and is dominated by a negative sin $2\theta$ term which grows strongly with energy so that P(120°) reaches as much as 40% at higher energies. The experimental values of $\sigma(\theta)$ and $P(\theta)$ are simultaneously described reasonably well over this energy range in terms of a two-level R-function formalism. Anomalous background effects are estimated by use of a square-well interaction potential. (auth)

15801 EXPERIMENTAL INVESTIGATIONS OF THE $^{12}$C(h,p)$^{14}$N REACTION MECHANISM. Haas, F.; Heusch, B.; Gallmann, A.; Bromley, D. A. (Laboratoire de Physique Nucleaire et d'Instrumentation Nucleaire, Strasbourg). Phys. Rev.; 188: 1625-39(20 Dec 1969).

Systematic studies on proton angular distribution and proton–$\gamma$-radiation angular correlations have been carried out on the $^{12}$C($^3$He,p)$^{14}$N reaction throughout the energy range $4.62 \leq E_h \leq 11.0$ MeV. Both direct and compound-system reaction amplitudes are present; however, the latter appear to dominate. Striking resonant phenomena are observed, and it is suggested that these correspond to quasigiant resonances in the excitation-energy

range from 17 to 23 MeV in $^{15}O$ having a particularly simple structure involving single-proton orbitals coupled to excited $^{14}N$ core configurations. A systematic correlation has been observed between the population of $|m| = 1$ magnetic substates of the 7.03-MeV state in the residual nucleus and the appearance of backward peaking in the corresponding proton angular distributions. A crude argument relating these phenomena to the participation of a heavy-particle direct stripping mechanism is suggested. (auth)

**15802** INVESTIGATION OF OCTUPOLE CORRELATIONS IN $^{16}O$. Ullah, Nazakat; Rowe, David J. (Univ. of Toronto). Phys. Rev.; 188: 1640-5(20 Dec 1969).

The reliability of various approximation procedures has been investigated for the low-lying $J^\pi = 3^-$, $T = 0$ state in $^{16}O$ and the associated ground-state correlations. To see the effects of emphasizing or suppressing the octupole correlations, a conventional shell-model Hamiltonian was used but addition (or subtraction) of various amounts of an octupole–octupole interaction. Comparison with an exact diagonalization, within the limited model space, shows that the equations of motion, in the particle-hole approximation, give excellent results in the vibrational region of small octupole correlations. The results are much better than those of the random-phase approximation, which ignores the Pauli blocking effects of ground-state correlations. The procedure of variation of a deformed intrinsic determinant after angular momentum projection is found to be excellent in the rotational region of large octupole correlations. But already in the vibrational region, it is at least as good as the random-phase approximation, and would be even better if a more general intrinsic determinant were allowed. Both the equations-of-motion and the projection method give reasonable results in the transition region. (auth)

**15803** PARTIAL-WAVE ANALYSIS FOR CERTAIN SIMPLE SYSTEMS WITH APPLICATION TO THE REACTION $^{16}O(d,\alpha)^{14}N$. Jolivette, P. L.; Richards, H. T. (Univ. of Wisconsin, Madison). Phys. Rev.; 188: 1660-4(20 Dec 1969).

The angular distributions of spin-zero even-parity particles emerging from a compound nucleus formed by a $1^+$ and $0^+$ pair are displayed in a simple form which facilitates parametrizing the differential cross section in terms of partial waves. The method is applied to the $^{16}O(d,\alpha_1)^{14}N^*$ data of Jobst et al. to display the resonant partial waves corresponding to $^{18}F$ states. Intrinsically ambiguous solutions of number $2^{l_{max}}$ are found empirically. The problem of selecting the correct solution is discussed. Data with polarized deuterons are of no help since the analyzing powers are energy-dependent (cf. Jacobsohn and Ryndin, who first noted that the reaction is an absolute detector of deuteron alignment). (auth)

**15804** NUCLEAR INTERACTION OF OXYGEN WITH OXYGEN. Maher, J. V.; Sachs, M. W.; Siemssen, R. H.; Weidinger, A.; Bromley, D. A. (Yale Univ., New Haven). Contract AT(30-1)-3223. Phys. Rev.; 188: 1665-82(20 Dec 1969).

Striking and regular gross structure has been observed in excitation functions for the $^{16}O + ^{16}O$ elastic scattering interaction in the oxygen-ion laboratory energy range from 20 to 80 MeV. Excitation functions have been measured simultaneously at five c.m. angles from 50° to 90°; systematic angular-distribution measurements have been carried out at narrow energy intervals spanning the gross-structure peak in the 90° excitation function for $19 \leq E_{c.m.} \leq 22$ MeV and at intervals throughout the remainder of the energy range studied. The gross structure is reproduced surprisingly well by a Woods-Saxon optical model having an unusually shallow real well depth (V = 17 MeV) and an energy-dependent imaginary well depth ($W = 0.4$ MeV $+ 0.1\,E_{c.m.}$). Extensive scans have demonstrated that this is the lowest member of a discrete set of equivalent Woods-Saxon potentials; it is the only one of these, however, which provides a reproduction of the experimental data without requiring a marked and complex energy dependence of the real potential-well depth. The effects of adding a repulsive core to this lowest Woods-Saxon potential were studied in some detail; it has been found that the model predictions are quite sensitive to the core—a somewhat surprising result, perhaps reflecting the apparent long mean free path of the $^{16}O$ ions under the present conditions. An ambiguity in the imaginary well depth has been examined in some detail; the present data do not permit resolution of this ambiguity, but throw into question the physical significance of this long mean free path. The addition of a core does not provide significantly improved fits to the experimental data. This does not preclude the existence of the core, but suggests further study with different well parameters and shapes. A phase-shift analysis of the 28 angular distributions spanning the gross-structure peak provided no evidence for underlying resonances; no compelling explanation for the intermediate (~200-keV) width structure superposed on the gross-structure peak is yet available. Finer-grained excitation-function structure is present and is attributed to statistical fluctuations in the usual way. Extensive theoretical studies stimulated by, and concurrent with, these experimental studies have demonstrated that these heavy-ion data may provide unique information on the nuclear-matter problem in finite systems, including an experimental determination of the effective nuclear compressibility. (auth)

**15805** $^{14}N$–$^{14}N$ AND $^{14}N$–$^{16}O$ ELASTIC SCATTERING. Jacobson, L. A. (Univ. of Wisconsin, Madison). Phys. Rev.; 188: 1509-16(20 Dec 1969).

Differential cross sections at 40 to 50° angles (35° to 110° cm) for $^{14}N$–$^{14}N$ and $^{14}N$–$^{16}O$ elastic scattering are reported. The cm energies vary in steps of 200 keV from 5 MeV to ~18 MeV. For $^{14}N$–$^{14}N$, some additional data extend to ~20 MeV. Only at the lower energies does either the optical model or a modified diffraction model satisfactorily describe the data. At the higher energies, weak but broad peaks appear in the excitation curves. Evidence concerning finer structure is inconclusive. (auth)

**15806** $^{10}B$ LEVELS FROM ELASTIC SCATTERING OF PROTONS BY $^9Be$. Mo, Tsan; Hornyak, W. F. (Univ. of Maryland, College Park). Phys. Rev.; 187: 1220-33(20 Nov 1969).

The level structure in $^{10}B$ was investigated through the $^9Be(p,p)$ $^9Be$ reaction in the energy region $0.8 < E_p < 1.8$ MeV. The differential cross section for elastically scattered protons from thin, evaporated $^9Be$ targets was measured in 1- to 10-keV intervals at cm angles of 54.7, 76.0, 90.0, 125.3, and 161.0°. A 180° double-focusing magnetic spectrometer was used in analyzing the scattered protons at the first four angles, while a high-resolution solid-state detector was used in obtaining the data at 161.0°. The data were fitted by a "multilevel" formula derived from R-matrix theory. Besides the "distant" level contribution, up to three resonance levels of the same spin and parity could be included in the theoretical fitting. Spectroscopic assignments and widths were determined and are discussed for seven resonance levels exhibiting relatively strong proton partial widths, at 945-, 980-, 922-, 1084-, 1200-, 1340-, and 1650-keV incident proton energies. The determined spins and parities are $1^-$, $2^+$, $2^-$, $0^+$, $1^+$, $2^-$, and $2^+$, respectively. Total widths $\Gamma$ (keV, in the cm system) and the partial-proton-width to total-width ratios $\Gamma_p/\Gamma$ corresponding to these levels are 130, 0.38.; 65, 1.0; 80, 0.90; 3.3, 1.0; 250, 0.30; 265, 0.90; and ~800, <0.2. In general, these are in agreement with the earlier published data, although some of the ratios $\Gamma_p/\Gamma$ are higher than those previously reported. Uncertainties of some earlier $J^\pi$ assignments were resolved. Extensive fittings of the data confirmed the existence of the resonance at $E_p = 980$ keV. (auth)

**15807** INELASTIC SCATTERING OF PROTONS FROM $^{10}B$ BETWEEN 5 AND 16.5 MeV. Watson, B. A. (Indiana Univ., Bloomington. Argonne National Lab., Ill.); Segel, R. E.; Kroepfl, J. J.; Singh, P. P. Phys. Rev.; 187: 1351-64(20 Nov 1969).

Angular distributions for inelastically scattered protons leading to the 0.717-, 1.74-, 2.15-, 3.59-, 4.77-, and 6.04 MeV states in $^{10}B$ were measured in 300-keV steps between 5 and 12 MeV and in 500-keV steps from 12 to 16 MeV. Yield curves for protons feeding these states were measured in 100-keV steps from 5 to 16 MeV at five angles. Resonance structures in the region $5 \leq E_p \leq 10$ MeV were observed in the yield curves. The observed cross section for formation of the 6.04-MeV state was five times that for any of the lower-lying levels. A weak correspondence between the total cross section for formation of these states and its radiative-decay width $\Gamma$ (E2) is noted. The experimental differential cross sections are compared with distorted-wave Born-approximation calculations. While the calculations are not in quantitative agreement with the experimental cross sections, some conclusions can be drawn from their qualitative similarities. (auth)

**15808** THREE-ALPHA MODEL OF $^{12}C$ NUCLEUS. Leung, C. C. H.; Park, S. C. (Baylor Univ., Waco, Tex.). Phys. Rev.; 187: 1239-45(20 Nov 1969).

The $^{12}C$ nucleus is studied from the three-$\alpha$-particle point of view based on a wave-function method in which the Hermiticity of the Fredholm kernel is preserved. The interaction between two $\alpha$ particles, obtained from the resonating-group calculation of Okai and Park, is recast in a separable form with the aid of Hille's formula. For the numerical calculation, three simpler types of the potential: Gaussian, Tabakin, and Yamaguchi are employed. It is shown that Harrington's theory, based on the T-matrix method, reduces to a result of the present study, but not to those of other wave-function methods. Contrary to a conclusion of the previous work, an excited state with the same $(J,\pi)$ as the ground state was found. The present method also supplies the mean height and side of the equilateral triangles formed by three $\alpha$

particles. These values are found to imply a root-mean-square radius of the $^{12}C$ nucleus which agrees well with the experimental value. (auth)

15809 ENERGY DEPENDENCE AND SPECTROSCOPY OF THE $^{16}O(p,d)^{15}O$ REACTION. Snelgrove, J. L.; Kashy, E. (Michigan State Univ., East Lansing). Phys. Rev.; 187: 1246-58(20 Nov 1969).

A systematic study of the extraction of spectroscopic factors for the (p,d) reaction on light nuclei and the difficulties encountered in obtaining reasonable distorted-wave Born approximation (DWBA) fits to the shapes of the angular distributions was made. Deuteron spectra and angular distributions were measured for the $^{16}O(p,d)^{15}O$ reaction for 21.27-, 25.52-, 31.82-, 38.63-, and 45.34-MeV incident protons. The elastic scattering of protons from $^{16}O$ was measured over the same energy range and used to obtain proton optical-model parameters. Present results indicate that consistent spectroscopic information can be obtained from DWBA calculations when the deuterons in the exit channel have an energy greater than 20 MeV. Approximately 30% of the $1p_{\frac{1}{2}}$ strength appears to be missing from the 6.18-MeV, $\frac{1}{2}^-$ level of $^{15}O$, and a large fraction of that strength appears in the 9.60- and 10.46-MeV levels. Small 2s-1d admixtures were observed in the ground state of $^{16}O$, and excitation of a $\frac{1}{2}^+$ level is observed. This excitation is a possible candidate for a two-step excitation process. (auth)

15810 POLARIZATION OF NEUTRONS FROM THE $^{11}B(d,n)^{12}C$ REACTION AT 2 MeV. Miller, T. G. (Army Missile Command, Redstone Arsenal, Ala.); Biggerstaff, J. A. Phys. Rev.; 187: 1266-8(20 Nov 1969).

The polarization of five groups of neutrons was measured at 2.0-MeV deuteron bombarding energy for the $^{11}B(d,n)^{12}C$ reaction corresponding to the ground, 4.43-, 7.66-, 9.66-, and 12.76-MeV states of $^{12}C$. A liquid-helium time-of-flight neutron polarimeter was used to make the measurements. The polarization of the neutrons to the ground state and first excited state in $^{12}C$ is positive at forward angles and negative at back angles. The polarization of neutrons to the 7.66-MeV level in $^{12}C$ is negative for angles less than 130°. The polarization of neutrons to the 9.66- and 12.66-MeV levels is negative at forward angles and positive beyond 50°. (auth)

15811 $^8Be$ STATES AT 16.6 AND 16.9 MeV AND FINAL-STATE COULOMB INTERACTIONS. Ingram, F. D.; Norbeck, E. (Univ. of Iowa, Iowa City). Phys. Rev.; 187: 1302-5(20 Nov 1969).

The shape, width, and location of the 16-MeV resonances in the $\alpha$-particle energy spectrum from the $^6Li(^6Li,\alpha)^8Be$ reaction were found to be a function of the angle taken by the breakup fragments in the subsequent decay of the $^8Be$. This was caused by the long-range electrostatic interaction between the $\alpha$ particle and the breakup particles. (auth)

15812 PHOTONUCLEAR DISINTEGRATION AT HIGH (<350 MeV) ENERGIES. Gabriel, Tony Alexander. Knoxville, Tenn.; Univ. of Tennessee (1969). 105p.

Thesis.

Calculations of high-energy ($40 \lesssim E\gamma \lesssim 300$ MeV) photon-nucleus ($A \gtrsim 12$) collisions were carried out. The results of the initial interaction of the photon with the nucleus are obtained either from the quasi-deuteron model of Levinger or, when energetically possible, from one of the four pion, nucleon states formed in photon-nucleon interactions. The effect of the subsequent nucleon- (pion-) nucleus interactions that follow the initial photon interaction is taken into account by using an intranuclear-cascade model. The results of the calculations are compared with a variety of experimental data, and good agreement is obtained. (Diss. Abstr.)

15813 SYSTEMATICS OF COULOMB-DISTORTION EFFECTS IN LARGE-ANGLE M1 ELECTROEXCITATION. Chertok, B. T. (American Univ., Washington, D. C.). Phys. Rev.; 187: 1340-7(20 Nov 1969).

Computer calculations of inelastic electron scattering for M1 transitions in light nuclei are carried out for very low-energy electrons, $E_0 < 5$ MeV, and low-energy electrons $10 < E_0 < 70$ MeV. The calculation is a partial-wave analysis using the Duke program. Computer results are presented graphically as the Coulomb distortion versus Z, $E_0$, k, and $\theta$. The dependence of the assumed nuclear model on the calculation is examined. Numerical results are presented leading to a revision of the radiative width $\Gamma_0$ for the 15.1-MeV state of $^{12}C$. Revised widths are presented for other M1 transitions in $^{16}B$, $^{28}Mg$, and $^{28}Si$. With regard to the $^{12}C$ width, the present status of the conserved-vector-current test in $^{12}B$, $^{12}C$, and $^{12}N$ is discussed. Finally, the numerical significance of Coulomb effects in the M1 breakup of the deuteron by electrons with $E_0 < 100$ MeV is presented. The small Coulomb-distortion effect is compared with estimates of meson exchange currents in D(e,e')np. (auth)

15814 THREE-BODY MODEL OF $^6Li$ AND DEUTERON-ALPHA-PARTICLE SCATTERING. Shanley, Paul E. (Univ. of Notre Dame, Ind.). Phys. Rev.; 187: 1328-39(20 Nov 1969).

The properties of $^6Li$ and deuteron-$\alpha$-particle scattering are studied in an exact three-particle model in which the neutron, proton, and $\alpha$ particle interact through separable two-body forces. The $\alpha$ particle is assumed to be structureless, and Coulomb effects are neglected. As a representation of the nucleon-$\alpha$-particle interaction, a three-term separable potential fit to low-energy neutron-$\alpha$-particle scattering is introduced in the partial waves $s_{\frac{1}{2}}$, $p_{\frac{3}{2}}$, and $p_{\frac{1}{2}}$. The $s_{\frac{1}{2}}$ interaction is taken to be repulsive, while the other two are attractive. The three-body formalism of Amado is generalized to allow spin-dependent two-body interactions in an arbitrary partial wave. Numerical solution of the resulting three-body equations gives the binding energies of the T = 0 and T = 1 states of $^6Li$ as well as phase shifts, angular distributions, and deuteron polarization in d-$\alpha$ scattering, and also the total cross section for $d + \alpha \rightarrow n + p + \alpha$ up to 30 MeV. Most of the calculations have used only an s-wave n-p interaction, but a limited number have been done with the d state of the deuteron included in order to assess its importance. Given the assumptions of the model, the agreement of the calculated quantities with experiment is very good. Some discussion of the results with respect to phenomenological optical-model fits to deuteron-nucleus scattering is also given. (auth)

15815 PROPERTIES OF ELECTROMAGNETIC TRANSITIONS IN $^{13}C$. Wittwer, G.; Clerc, H.-G.; Beer, G. A. (Technische, Hochschule, Darmstadt, Ger.). Phys. Lett.; 30B: 634-6(22 Dec 1969).

Transitions to seven levels below 16 MeV excitation energy were studied by using low-energy scattering. For the $T = \frac{3}{2} \rightarrow \frac{1}{2}$, 15.11 MeV transition, which is of interest in connection with a possible isotensor electromagnetic interaction, the M1 and E2 radiative widths were measured with high precision. Electric monopole excitation of $\frac{1}{2}^-$ levels was found. (auth)

15816 CLUSTER-MODEL INTERPRETATION OF RESONANCES IN $\alpha$-PARTICLE ELASTIC SCATTERING. Cowley, A. A.; Heymann, G. (South African Council for Scientific and Industrial Research, Pretoria). Phys. Lett.; 30B: 618-20(22 Dec 1969).

Evidence for a cluster-model interpretation of a large-angle resonance, observed in the elastic scattering of $\alpha$-particles from $^{16}O$, is produced. Observation of the same resonance in the reaction $^{17}O(^3He,\alpha)^{16}O$ (ground state) is considered to be significant. (auth)

15817 THE $^{12}C(^6Li,t)^{16}O$ REACTION AT 20 MeV. Bassani, G.; Kruse, T. H.; Saunier, N.; Souchere, G. (CEN, Saclay, France). Phys. Lett.; 30B: 621-3(22 Dec 1969).

States in $^{16}O$ up to an excitation energy of 16.9 MeV were observed from the $^{12}C(^6Li,t)^{16}O$ reaction at 20 MeV. Differential cross sections were obtained from $\theta_{lab} = 15°$ to 105° for the triton groups corresponding to states in $^{16}O$ at 6.13, 6.92, 7.12, 8.87, 9.85, 10.35 and 11.09 MeV. (auth)

## Nuclear Properties and Reactions, $20 \leq A \leq 89$

*Refer also to abstracts 14032, 14294, 14492, 15474, 15475, 15495, 15627, 15791, 15794, 15797, 15955, 15957, 15981–15983, and 15999.*

15818 (CEA-R-3856) CONTRIBUTION TO THE SPECTROSCOPY OF 50 NEUTRON ISOTONES. Picard, Jean (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1969. 127p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Paris Univ., Orsay, France.

Proton states in the isotones N = 50 were studied through the reaction ($^3He$,d) on $^{88}Sr$, $^{90}Zr$ and $^{92}Mo$ target nuclei with 18-MeV $^3He$ projectiles. Also, neutron hole states were studied using the ($^3He$, $\alpha$) reaction on the same targets. The information thus obtained on independent quasi-particle or hole states completes the set of experimental data required for a microscopic description of the collective properties of the even isotones $^{88}Sr$, $^{90}Zr$ and $^{92}Mo$ in the framework of BCS(IGE) + RPA theories. The results of this calculation are compared to experimental data and, more particularly, the results of 20-MeV proton inelastic scattering on

$^{88}$Sr are analyzed using antisymmetrized with the microscopic wave functions calculated previously. (auth)

**15819** (UCRL-19338) NUCLEAR SPINS, $^3P_1$ AND $^3P_2$ HYPERFINE STRUCTURES, AND NUCLEAR MOMENTS OF $^{69}$Ge AND $^{75}$Ge, AND $^3P_2$ HYPERFINE STRUCTURE OF $^{71}$Ge. Oluwole, Abiodun F. (California Univ., Berkeley. Lawrence Radiation Lab.). 10 Sep 1969. Contract W-7405-eng-48. 95p. Dep. CFSTI.

Thesis.

The atomic-beam magnetic-resonance (ABMR) technique was used to measure the nuclear spin, I, and the $^3P_1$ hyperfine structure (hfs) constants, a and b, for 37-hr $^{69}$Ge, the $^3P_2$ hfs constant a for 11-day $^{71}$Ge, and the nuclear spin and hfs constant a for $^{75}$Ge in the $^3P_1$ and $^3P_2$ electronic states. The nuclear moments were inferred by the use of the Fermi–Segrè formula from the corresponding hfs interaction constants. (auth)

**15820** THE EXCITED LEVELS OF $^{79}$Br. Weiss, J.; Langhoff, H.; Schumacher, M. (Univ., Goettingen, Ger.). Z. Phys.; 230: 371-82(1970). (In German).

Previous investigations of nuclear resonance fluorescence from $^{79}$Br were improved by using a Ge-detector. In addition, energies and intensities of the $\gamma$ transitions initiated by the decay of $^{79}$Kr were remeasured. Coincidences between the $\gamma$ transitions were investigated using two 40 ccm Ge-detectors. 14 $\gamma$ transitions unknown up to the present were identified. A level scheme having 12 excited states is proposed. Unique assignments of spin and parity to the 7 lowest states became possible by the present and former experimental data. (auth)

**15821** INVESTIGATION OF LOW-LYING LEVELS IN $^{54}$Fe BY THE (p,p'$\gamma\gamma$) REACTION. Kreische, W.; Lampert, W.; Loos, G.; Weitle, D. (Univ., Erlangen-Nuremberg). Z. Phys.; 230: 337-57(1970). (In German).

The low-lying levels of $^{54}$Fe were studied. The method of $\gamma\gamma$-triple-correlations was used. Angular distributions were also measured. The levels at 2.5 MeV were found to be a doublet, with $I = 0^{(+)}$ for the 2563 keV-level and $I = 4^{(+)}$ or $2^{(+)}$ for the lower level at 2539 keV. The experimental level scheme is compared with calculations according to nuclear models. (auth)

**15822** STUDIES IN NUCLEAR AND ATOMIC PHYSICS UTILIZING HIGH-RESOLUTION SEMICONDUCTOR PHOTON SPECTROMETERS. Kostroun, Vaclav Otakar. Eugene, Oreg.; Univ. of Oregon (1968). 83p.

Thesis.

The recent development of semiconductor photon detectors with a resolution ≤1 keV in the x-ray region has opened a new range of experimental possibilities in low-energy nuclear and atomic physics. The construction and application of Si(Li) diode x-ray spectrometers with liquid-nitrogen cooled field-effect transistor preamplifiers are described. Solid-state photon detectors were used in three experiments: $\beta$-feeding of the $\underline{d}$ hole state in $^{41}$Sc was studied through $\gamma$-ray spectroscopy; the total internal conversion coefficient of the 23.9-keV ground-state transition in $^{119m}$Sn, of interest in Mössbauer studies, was determined, and the $\underline{L_2}$–$\underline{L_3N}$ Coster-Kronig (radiation-less) transition probabilities in Hg and Pb were measured. Theoretical total $\underline{L_2}$–$\underline{L_3N}$ radiation-less transition probabilities for Hg and Pb were derived in $\underline{LS}$ coupling. (Disser. Abstr.)

**15823** CORE EXCITATION OF $^{20}$Ne. Borse, G. J. (Lehigh Univ., Bethlehem, Pa). Nuovo Cim., Lett.; 2: 659-62(11 Nov 1969).

The core-excited states of $^{20}$Ne using the $SU_3$ classification scheme. A Gaussian residual interaction with a Rosenfeld exchange mixture was used. (J.W.R.)

**15824** INELASTIC SCATTERING OF 14.2 MeV NEUTRONS FROM $^{31}$P AND $^{32}$S. Bonazzola, G. C. (Univ., Turin. Istituto Nazionale di Fisica Nucleare, Turin); Bressani, T.; Chiavassa, E.; Maringelli, M. Nuovo Cim., Lett.; 2: 667-8(11 Nov 1969).

The time-of-flight method was used to study the inelastic scattering of 14.2-MeV neutrons from $^{31}$P and $^{32}$S. Angular distributions were measured for neutron peaks corresponding to excitation of 3- to 6-MeV levels in $^{31}$P and $^{32}$S. (J.W.R.)

**15825** STUDY OF THE (d,$^3$He) REACTION ON CHLORINE ISOTOPES. PUTTASWAMY, N. G.; Yntema, J. L. (Argonne National Lab., Ill.). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 1-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The (d,$^3$He) reaction on $^{35}$Cl and $^{37}$Cl was studied at a deuteron beam energy of 23.35 MeV. A 60-in. scattering chamber along with a (dE/dx) – E counter arrangement was used for identifying the $^3$He particles. $^3$He spectra were taken between laboratory angles of 12 and 30°. The experimental angular distributions were compared with local and zero-range DWBA calculations. The spectroscopic factors for $^{34}$S and $^{36}$S were compared with shell-model calculations. (J.W.R.)

**15826** STATES IN $^{27}$Al AND $^{89}$Y. Crawley, G. M.; Powell, D. L.; Rao, B. V. N. (Australian National Univ., Canberra). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 6-11 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Energy levels in $^{27}$Al and $^{89}$Y were excited by inelastic scattering of 10- and 12-MeV protons. Proton spectra were measured with a resolution of 16 keV by a surface barrier detector. The states excited in $^{27}$Al and $^{89}$Y are compared with previous data. (J.W.R.)

**15827** LOW-LYING LEVELS OF $^{60}$Co FROM $^{59}$Co(n,$\gamma$)$^{60}$Co REACTION. Chintalapudi, Surya N.; Sastry, D. L.; Jnanananda, Swami (Andhra Univ., Waltair, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 19-22(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The low-lying levels of $^{60}$Co were studied through thermal neutron capture in $^{59}$Co. The $\gamma$–$\gamma$ coincidence spectra were measured and fitted into the decay scheme. The results are compared with other data and theoretical calculations. (J.W.R.)

**15828** ENERGY LEVELS OF $^{51}$V BY $^{48}$Ti($\alpha$,p) AND $^{50}$Ti($^3$He,d) REACTIONS. Maheshwari, P. N. (Bhabha Atomic Research Center, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 30-3(1968).

From Nuclear Physics and State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The energy levels of $^{51}$V were studied through the $^{48}$Ti($\alpha$,p) and $^{50}$Ti($^3$He,d) reactions. An E-$\Delta$E semiconductor detector was used to measure the proton and deuteron spectra. The angular distributions for the ($^3$He,d) reaction were compared with DWBA calculations. Spectroscopic factors and spin-parity assignments were determined for the $^{51}$V levels. (J.W.R.)

**15829** T = 2 STATE IN $^{28}$Si. Gupta, S. K.; Kerekatte, S. S.; Mehta, M. K. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 37-43(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The excitation functions for the reaction $^{27}$Al(p,$\alpha$) at 3.5 to 4 MeV were measured at angles of 60, 90, and 150°. A resonance at 3.865 MeV was identified as the lowest T = 2 state in $^{28}$Si. (J.W.R.)

**15830** ABSOLUTE TOTAL CROSS SECTION FOR THE REACTION $^{51}$V(p,n)$^{51}$Cr OVER THE ISOBARIC ANALOGUE RESONANCE NEAR 2.340 MeV. Sekharan, K. K.; Mehta, M. K. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 51-5 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The excitation function for the 2.340-MeV isobaric analog resonance in the $^{51}$V(p,n) reaction was measured. The partial widths and spreading width for the resonance were determined and the spectroscopic factor was estimated. (J.W.R.)

**15831** THE $^{28}$Si($\alpha$,n)$^{31}$S REACTION CROSS SECTION FROM 3.0 TO 5.4 MeV. Balakrishnan, M.; Sekharan, K. K.; Mehta, M. K.; Divatia, A. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 57-60(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The excitation function $^{28}$Si($\alpha$,n) reaction at 3.0 to 5.4 MeV was measured. The neutrons were detected using a 4$\pi$-counter. The excitation function for the reaction was measured in 5-keV steps. A large number of narrow levels in the compound nucleus $^{32}$S with average widths of about 10 keV were seen. The data were compared with a similar experiment over the same energy range. (J.W.R.)

**15832** ENERGY LEVELS IN $^{75}$Se AND $^{71}$Ge. Baliga, B. B.; Basu, B.; Patro, A. P. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 72-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The deexcitation $\gamma$ spectra following the $^{75}$As and $^{71}$Ga(p,n) reac-

tions were measured using a Ge(Li) detector. The observed γ rays were fitted into the $^{75}$Sc and $^{71}$Ge level schemes. (J.W.R.)

15833 NUCLEAR TEMPERATURES FROM NEUTRON-INDUCED REACTIONS AT 14 MeV INCIDENT ENERGY. Cheema, T. S.; Hans, H. S. (Panjab Univ., Chandigarh, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 92-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The proton spectra from (n,p) reactions at 14-MeV neutron energy were analyzed to investigate any systematics in the behavior of direct interaction effects. A shape analysis was performed for experimental proton energy spectra from the published literature. The nuclear temperatures were obtained and compared with nuclear temperature from other reactions. (J.W.R.)

15834 OPTICAL POTENTIAL FOR DEUTERONS. Mukherjee, S.; Satpathy, R. K.; Samaddar, S. K. (Saha Inst. of Nuclear Physics Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 97-100(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The deuteron optical potential consisting of neutron and proton optical potentials summed over the deuteron internal motion is discussed. Some results for deuteron scattering on copper and zinc are presented. (J.W.R.)

15835 A SHELL MODEL DESCRIPTION OF ISOBARIC ANALOGUE STATES IN $^{20}$Ne AND $^{24}$Mg. Ananthanarayanan, K. (MATSCIENCE, Madras). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 239-44(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The lowest T = 2 states in $^{20}$Ne and $^{24}$Mg are investigated in a shell-model calculation. Pure $(^1d_{\frac{5}{2}})^4$ configurations are assumed for both nuclei. The energy gap between the $^{20}$Ne T = 2, J = $0^+$ and T = 0, J = $0^+$ levels was about 6.7 MeV low but the M1 and beta decay rates were in good agreement with experiment. The calculations for $^{24}$Mg indicate that a single configuration is inadequate. (J.W.R.)

15836 HALF-LIVES OF THE EXCITED STATES OF $^{37}$Cl, $^{38}$A, $^{41}$K, $^{88}$Sr, $^{131}$Xe, AND $^{186}$Os. Pathak, B. P.; Murthy, K. S. N.; Gujrathi, S. C. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 289-92(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The half-lives of the excited states of several nuclei were measured by means of the delayed coincidence technique, employing a time-to-amplitude converter and a 512-channel analyzer. Two plastic scintillators, one of 2.5 cm × 3 mm and the other of 2.5 cm × 2.5 cm are used to detect the beta and gamma radiations, respectively. The scintillators are mounted on RCA 7850 photomultipliers. The source is in contact with the beta detector and a beta absorber of suitable thickness is placed on the gamma detector. The half-lives were determined by the centroid shift method and from the slope of the delayed coincidence curve, whenever possible; computer programmes were written for these analyses. (auth)

15837 LIFE-TIMES OF THE EXCITED STATES IN $^{75}$As, $^{123}$Sb, $^{147}$Pm, AND $^{199}$Hg. Singh, H.; Sethi, B.; Murthy, K. S. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 298-302(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The life-times of the excited states of a few odd mass nuclei were measured by the delayed coincidence technique using a time to amplitude converter. The detectors used were plastic scintillators coupled to RCA 7850 photomultipliers. The beta- and gamma-rays were detected with a 2.5 cm diam. × 3 mm thick NE 810 and a 2.5 cm diam. × 2.5 cm. thick NE 102 plastic scintillators respectively. Suitable aluminium absorbers were placed between the source and the gamma detector in order to absorb the beta-rays. A 512 channel analyzer was used to record the delayed and prompt time-spectra. The lifetimes were determined either by calculating the moments of the delayed and prompt curves or from the slopes of the delayed curves, depending on the values of the lifetimes to be measured. Computer programs were written for analyses of moments, least squares fitting of the exponential parts of the delayed time-spectra, and the calculation of random errors. (auth)

15838 PROJECTED HARTREE- FOCK METHOD AND STRETCH SCHEME ENERGY LEVELS OF $^{44}$Ti. Khadkikar, S. B.; Banerjee, B. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 315-18(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The energy levels of $^{44}$Ti were calculated using the projected Hartree-Fock method and the stretch scheme. Isobaric spin T = 0 was assumed in the stretch scheme calculations. The PHF levels are much lower than the stretch scheme levels, but the overall nature of the spectrum is the same for both methods. (J.W.R.)

15839 ANGULAR CORRELATION STUDIES OF THE REACTION $^{28}$Si(α,α′)$^{28}$Si$_{1.77}$(γ)$^{28}$Si. Ahlfeld, Charles Edward. Tallahassee; Florida State Univ. (1968). 137p.

Thesis.

Alpha-gamma angular correlations for the reaction $^{28}$Si(α,α′)-$^{28}$Si$_{1.77}$(γ)$^{28}$Si were measured in the reaction plane at laboratory bombarding energies of 10.0, 12.0, 14.0 and 18.0 MeV. These measurements were made at α particle scattering angles from 12 to 170° (lab) in 3° steps. The correlations were least-squares fit to the in-plane angular correlation function $W = A + C\sin^2(\phi_\gamma - \phi_2)$ and the parameters A, C, and $\phi_2$ were extracted. In addition α angular distributions were obtained for the ground state and first three excited states (1.77, 4.61, and 4.97 MeV) at 18.0 MeV bombarding energy. At 10.0, 12.0 and 14.0 MeV the elastic and first inelastic angular distributions were measured. The angular range for each distribution was from approximately 20 to 170° (lab) in 2.5° steps. The 10.0, 12.0, and 14.0 MeV correlation data were fit with a limited L-value calculation which assumes that the number of partial waves dominating the interaction is small. The 18.0 MeV angular correlation and distribution data were analyzed by a non-adiabatic coupled-channel calculation employing both rotational and vibrational coupling schemes. The results of these calculations show fair agreement with the correlation data and good agreement with the elastic and first inelastic α angular distributions. (Diss. Abstr. Int., B)

15840 INTERNAL BREMSSTRAHLUNG ACCOMPANYING THE ELECTRON-CAPTURE DECAY OF $^{54}$Mn. Lancman, H.; Lebowitz, Jacob M. (Brooklyn Coll.). Phys. Rev.; 188: 1683-5(20 Dec 1969).

The internal-bremsstrahlung spectrum accompanying the decay of $^{54}$Mn was investigated. The spectrum was compared with the theoretical predictions of Martin and Glauber using a computer fitting routine. The decay energy corresponding to the transition to the first excited state of $^{54}$Cr was found to be 512 ± 25 keV. The intensity of the total internal bremsstrahlung in the energy range 100 to 420 keV was found to be $(0.65 \pm 0.15) \times 10^{-4}$ per 1S capture as compared to the theoretical value of $1.01 \times 10^{-4}$. (auth)

15841 CROSS SECTIONS OF FRAGMENTS EMITTED IN SPALLATION REACTIONS OF CARBON AND NITROGEN WITH 90-MeV α PARTICLES. Jung, M.; Jacquot, C.; Baixeras-Aiguabella, C.; Schmitt, R.; Braun, H.; Girardin, L. (Centre de Recheres Nucleaires, Strasbourg). Phys. Rev.; 188: 1517-19(20 Dec 1969).

The yield of fragments of mass 6 to 14 emitted in 90-MeV α-particle interactions with an emulsion of C and N nuclei was calculated. The experimental cross sections were fitted with a relation similar to Rudstam's, and an application of the results was made to the determination of some isotopic ratios. (auth)

15842 SPECTRA OF γ-RAYS FROM $^{64}$Ni(n,γ)$^{65}$Ni REACTION. Bogdanov, A. P.; Soroka, A. V.; Tadeush, V. N.; Firsov, E. I.; Khil'manovich, A. M. (Minsk Inst. of Physics). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Mat. Navuk; No. 5, 130-2(1969). (In Russian).

A magnetic Compton γ spectrometer and scintillation spectrometer of γ-γ coincidences were used in measuring the γ-γ coincidence spectra from the capture of thermal neutron by $^{64}$Ni. Gamma transitions from the initial state of $^{65}$Ni to the lower levels 0.06, 0.31, 0.70, and 1.40 MeV were observed. A method was found for discharging these levels to the ground state. (tr-auth)

15843 SPECTRA OF γ-RAY COINCIDENCES IN (n,γ) REACTIONS IN $^{57,58}$Fe ISOTOPES. Bogdanov, A. P.; Soroka, A. V.; Tadeush, V. N.; Firsov, E. I. (Minsk Inst. of Physics). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Mat. Navuk; No. 5, 127-9(1969). (In Russian).

A scintillation coincidence spectrometer was used in studies of γ-ray spectra accompanying the thermal neutron capture by $^{57,58}$Fe. Analysis of coincidence spectra revealed the method of decay in lower excited states of $^{58}$Fe up to 3.53 MeV. Direct transitions from the ground state in (n,γ) reaction were found only for the 0.29- and 0.73-MeV levels of $^{59}$Fe. (tr-auth)

15844 DECAY OF NEUTRON-DEFICIENT NUCLIDES OF MASS 89. Hagenauer, Richard Carl. Knoxville, Tenn.; Univ. of Tennessee (1969). 125p.

Thesis.

The decays of 78-hr $^{89}$Zr and 4-min $^{89m}$Zr were investigated using Ge(Li) γ-ray detectors. It was established that decay of 78-hr $^{89}$Zr populates the levels at 909.2, 1744.5, 2530.0, 2566.5, and 2622.1 keV in $^{89}$Y; and the decay of 4-min $^{89m}$Zr populates the level at 1507.4 keV in $^{89}$Y. The spin assignments were made from log ft values and previously reported data from studies of nuclear reactions. The half-lives of $^{89}$Zr and $^{89m}$Zr were measured to be 78.0 ± 0.2 hr and 4.16 ± 0.06 min, respectively. The levels of $^{89}$Y are compared with previously reported levels determined from nuclear reaction studies. The decays of 122-min $^{89}$Nb and 66-min $^{89m}$Nb were investigated using Ge(Li) and NaI(Tl) γ-ray and anthracene β-ray detectors. Coincidence relationships among the γ-rays were established in γ-γ coincidence experiments. The decay of $^{89}$Nb populates levels at 588.8, 1095.5, 1451.8, 1512.2, 1627.8, 1865.6, 2102.0, 2129.0, 2299.5, 2573.5, 2613.1, 2754.6, 2890.5, 2926.4, 2961.1, 2983.5, 3017.4, 3093.5, 3467.0, 3513.3, 3557.8, 3576.3, 3839.1 and 3965.5 keV in $^{89}$Zr. The decay of $^{89m}$Nb populates levels at 588.8, 1095.5, 1746.0, and 1865.6 keV in $^{89}$Zr. Some spin assignments were made from log ft values and the selection rules for gamma decay. The fraction of positron decay to the ground state was found to be 74%. Three beta rays of energies 3.34 ± 0.10, 2.82 ± 0.12, and 2.38 ± 0.15 MeV were measured with an anthracene detector. The half-lives of $^{89}$Nb and $^{89m}$Nb were found to be 122 ± 4 min and 66 ± 2 min respectively. The levels of $^{89}$Zr were compared with levels determined from nuclear reaction studies and shell model calculations. A search for $^{89}$Mo and $^{89m}$Mo was conducted with Ge(Li) detectors. Despite rapid chemistry no growth of $^{89}$Nb and $^{89m}$Nb was observed. The upper limits for the half-lives of $^{89}$Mo and $^{89m}$Mo are 43 sec and 24 sec respectively. The excitation function for the $^{92}$Mo(p,p2n)$^{90}$Mo reaction was measured at energies from 25 to 62 MeV. (Diss. Abstr. Int., B)

**15845** STUDIES OF LOW LEVELS OF $^{79}$Br AND $^{81}$Br. Begzhanov, R. B.; Kobilov, O. Sh.; Sabirov, Kh. S. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk Uzb. SSR, Ser. Fiz.-Mat. Nauk; No. 5, 64-7(1969). (In Russian).

The gamma angular correlations in the decays of $^{79}$Kr and $^{81}$Se were measured for determining the quantum characteristics of $^{79}$Br and $^{81}$Br levels. Gamma-gamma coincidences and in the case of $^{81}$Br, β-γ coincidences, were measured in order to determine level lifetimes. The low-lying $5/2^-$ and $3/2^-$ levels of both nuclei were observed. (R.V.J.)

**15846** PROPERTIES OF $^{30}$P LEVELS FROM THE REACTION $^{28}$Si(p,γ)$^{30}$P. II. Harris, Gale I.; Hyder, A. K. Jr.; Walinga, J. (Aerospace Research Labs., Wright-Patterson AFB, Ohio). Phys. Rev.; 187: 1413-44(20 Nov 1969).

A previous investigation of the γ-ray decay schemes of 7 resonances in the reaction $^{28}$Si(p,γ)$^{30}$P in the range $E_p$ = 700–1750 keV was extended to 24 resonances in the range $E_p$ = 300–1800 keV. The new decay scheme studies were conducted with a 40-cc Ge(Li) detector. The spins, parities, isobaric spins, lifetimes, and transition multipolarity mixings for many resonances and bound states of $^{30}$P were determined from an extensive series of angular-correlation, linear-polarization, and Doppler-shift-attenuation measurements. New resonance information includes the discovery that resonances previously reported at $E_p$ = 1505, 1748, and 1772 keV are each doublets. The latter two have components at 1746 and 1749, and at 1773 and 1775 keV, respectively. The 1505-keV "resonance" was found to be a doublet with a separation of 0.7 ± 0.1 keV by means of high-resolution elastic-scattering measurements. Unique spin assignments for 15 and parity assignments for 11 resonance levels were obtained. The observed resonance strengths $(2J + 1)\Gamma_p\Gamma_\gamma/\Gamma$ vary between 0.077 and 14 eV. Several unusually broad odd-parity resonances were observed which have large reduced widths for p-wave and f-wave capture. The strong contribution of $1f_{7/2}$, $2p_{3/2}$, and $2p_{1/2}$ orbitals to the configuration of states near $E_x$ = 7 MeV in $^{30}$P is revealed. The influence of isobaric spin on the level structure and γ-ray decay properties is apparent. The $2^-$ resonances at $E_p$ = 1470 and 1686 keV and the $4^-$ doublet at 1505 keV are identified as T-admixed pairs. Significant revisions of the decay schemes of the 1.45-, 2.94-, 4.14-, 4.50-, and 4.92-MeV levels have resulted from the 40-cc Ge(Li) spectra. The "4.92-MeV level" is shown to be a doublet with components at 4.921 ± 0.002 and 4.945 ± 0.005 MeV. By combining results of the angular-correlation, linear-polarization, and lifetime measurements, the following $J^\pi$ assignments are derived for bound levels: 0.71($1^+$), 1.45($2^+$), 1.97($3^+$), 2.54($3^+$), 2.72($2^+$), 2.84($3^+$), 2.94($2^+$), 3.02($1^+$), 4.14($2^-$), 4.18($2^+$), 4.23($4^-$), 4.43($2^+$), 4.47($0^+$), 4.50($1^+$), 4.62($3^-$), 4.92($5^-$ or $3^-$), and 4.94(1). Previous T = 1 assignments for the bound levels at $E_x$ = 0.68, 2.94, 4.18, 4.47, and 4.50 MeV are strongly supported by the data. Prominent "analog-to-antianalog" M1 transitions similar to those in other s-d shell nuclei are observed. An average isospin impurity of 7% for levels below 7 MeV in $^{30}$P is derived from the set of E1 transition rates. On the average, the E2 transition rates have strengths slightly less than one Weisskopf unit. However, strong E2 enhancement is observed for the 2.94 → 0.68, 2.54 → 0, and 2.72 → 0 transitions which have strengths of 21, 15, and 9 Weisskopf units, respectively. Several of the observed odd-parity resonance and bound levels appear to correspond to T = 1 and T = 0 members of a two-nucleon spectrum with major components $(s_{1/2}f_{7/2})$, $(d_{3/2}f_{7/2})$, and $(s_{1/2}p_{3/2})$. (auth)

**15847** BETA DECAY OF $^{29}$Al. Harris, W. R.; Nagatani, K.; Alburger, D. E. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev.; 187: 1445-8(20 Nov 1969).

The β decay of $^{29}$Al was investigated by forming the activity in the $^{27}$Al(t,p)$^{29}$Al reaction at an incident triton energy of 3.1 MeV. β branches were studied by observing the subsequent $^{29}$Si γ-ray singles with NaI(Tl) and Ge(Li) detectors and γ–γ coincidences in two 3 × 3-in. NaI(Tl) detectors. In addition to the previously reported β branches to the 1273-, 2028-, and 2426-keV states in $^{29}$Si, a β branch to the 3069-keV level was observed. The $^{29}$Al β branches in percent and the corresponding log ft values for decays to the 1273-, 2028-, 2426-, and 3069-keV levels in $^{29}$Si were found to be 90.1 ± 1.0, 5.09 ± 0.01; 3.6 ± 0.4, 5.74 ± 0.05; 6.3 ± 0.5, 4.99 ± 0.04; and 0.027 ± 0.011, 6.16 ± 0.18, respectively. Measurements of the excitation energies of the first three excited states of $^{29}$Si yielded (in keV) 1273.3 ± 0.2, 2027.8 ± 0.4, and 2425.7 ± 0.4. It was also found that the 2426-keV level has a (0.4 ± 0.1)% γ branch to the 2028-keV level in $^{29}$Si. (auth)

**15848** STUDIES ON THE SHAPES OF $^{28}$Si, $^{32}$S, AND $^{36}$Ar VIA DEUTERON SCATTERING. Mermaz, M. C.; Whitten, C. A. Jr.; Bromley, D. A. (Yale Univ., New Haven). Contract AT(30-1)-3223. Phys. Rev.; 187: 1466-78(20 Nov 1969).

Deuteron elastic and inelastic scattering on $^{28}$Si, $^{32}$S, and $^{36}$Ar was studied with an 18-MeV deuteron beam. Optical-model and distorted-wave Born-approximation analyses of the experimental angular distributions were performed. The deformation parameters $|\beta_2|$ and $|\beta_3|$, extracted in this manner, are in accord with the corresponding parameters extracted from electromagnetic de-excitation lifetimes in those cases where the electromagnetic lifetimes of the states involved in the inelastic scattering have been measured. The experimental angular distributions were also analyzed through a coupled-channel approach. This method of analysis permitted extraction of more complete spectroscopic information concerning the nuclei under study, namely, the even-even N = Z nuclei in the second half of the 2s-1d shell. The conclusions drawn regarding $^{28}$Si from the present work are not definite; however, the indications are that $^{28}$Si has an oblate static deformation, with excited states comprising a K = 0 rotational band based on the ground state. The strong octupole vibration (the 6.88-MeV $3^-$ level) in $^{28}$Si is to some degree in contradiction with this conclusion. In the case of $^{32}$S, the results of the coupled-channel calculations indicate that the levels of $^{32}$S up to an excitation energy of 5 MeV are well explained on the assumption that $^{32}$S is an almost spherical vibrational nucleus. The results for $^{36}$Ar are quite similar to those for $^{32}$S; however, the data are unfortunately less clear, since a number of the most important levels appear in the experimental spectrum as unresolved doublets. Spherical shell-model calculations have been found to be in excellent accord with the spectroscopic factors for deuteron-induced stripping and pickup reactions on these nuclei. These data, together with extensive spectroscopic measurements on lighter-mass nuclei in the s-d shell, suggest that in moving into the shell from $^{16}$O a pronounced static prolate deformation develops rapidly, reaching its maximum in the vicinity of A = 21 – 23; subsequently, this deformation is reduced, and in the vicinity of A = 28 it reverses sign to yield a weak, poorly stabilized oblate shape, which by A = 32 has returned to a spherical equilibrium configuration which is retained to the end of the shell. These experimental findings are not reproduced by the simplest Hartree-Fock calculations, which predict a more pronounced oblate deformation in the upper half of the shell. (auth)

**15849** INELASTIC SCATTERING OF 14.4-MeV PROTONS BY THE EVEN ISOTOPES OF TITANIUM. Lutz, H. F.; Bartolini, W.; Curtis, T. H.; Klody, G. M. (Univ. of California, Livermore). Phys. Rev.; 187: 1479-86(20 Nov 1969).

Elastic and inelastic scattering of 14.4-MeV protons from isotopically enriched targets of $^{46,48,50}$Ti were studied. Angular distributions for many groups separated by more than 40 keV were obtained. The data were analyzed using the coupled-channel calculation. The vibrational collective model was used to describe the states of the bombarded nucleus. Several octupole states were found in both $^{46}$Ti and $^{48}$Ti but only one in $^{50}$Ti. These results were compared with the results of α-particle scattering on the same nuclei. It was found that a discrepancy exists between the results of the experiments in the magnitudes of the deformabilities obtained for the octupole states. Spins and parities of some states in

$^{48}$Ti and $^{50}$Ti were suggested. Electromagnetic transition rates were inferred from the deformabilities deduced from inelastic scattering data. (auth)

15850 $^{15}$N(p,d)$^{14}$N REACTION AT 39.8 MeV. Snelgrove, J. L.; Kashy, E. (Michigan State Univ., East Lansing). Phys. Rev.; 187: 1259-65(20 Nov 1969).

Energy spectra and angular distributions were obtained for the $^{15}$N(p,p)$^{15}$N and $^{15}$N(p,d)$^{14}$N reactions at 39.8 MeV. Spectroscopic factors were extracted for the levels in $^{14}$N populated by $l_n = 1$ pickup and were found to be in excellent agreement with intermediate-coupling predictions, which for this nucleus differ only slightly from j-j coupling. A width of 210 ± 30 keV was measured for the $J^\pi = 1^+$, T = 1 level at 13.72 MeV. Angular distributions for other levels populated in the $^{15}$N(p,d)$^{14}$N reaction are shown. (auth)

15851 $(\alpha,\alpha'\gamma)$ ANGULAR CORRELATION STUDIES OF SOME EXCITED STATES IN $^{24}$Mg, $^{26}$Mg, AND $^{28}$Si. Canada, T. R.; Bent, R. D.; Haskett, J. A. (Indiana Univ., Bloomington). Phys. Rev.; 187: 1369-77(20 Nov 1969).

A number of states in $^{28}$Si, $^{26}$Mg, and $^{24}$Mg were studied using the $(\alpha,\alpha'\gamma)$ reaction and the angular correlation method-II geometry of Litherland and Ferguson. In $^{28}$Si, spin and parity assignments of 1, $(6^+)$, and $1^-$ are made to the 7.38-, 8.51-, and 8.94-MeV states, respectively. The 4.90-MeV state in $^{26}$Mg is assigned $J^\pi = 4^+$. Earlier $J^\pi$ assignments to the $3^-$ 6.88-, $2^+$ 7.41-, and $2^+$ 7.93-MeV states in $^{26}$Si, and the $1^-$ 8.44-, $2^+$ 9.00-, and $1^-$ 9.15-MeV states in $^{24}$Mg are confirmed, as is an earlier value of the multipolarity mixing ratio of the 2.94 → 1.81 γ-ray transition in $^{26}$Mg. (auth)

15852 MAGNETIC TRANSITIONS IN $^{28}$Si EXCITED BY 180° ELECTRON SCATTERING. Fagg, L. W.; Bendel, W. L.; Jones, E. C. Jr.; Numrich, S. (Naval Research Lab., Washington, D. C.). Phys. Rev.; 187: 1378-83(20 Nov 1969).

States in $^{28}$Si were excited by 180° electron scattering at bombarding energies of 39 and 56 MeV. Three strong M1 transitions excited levels at 10.86, 11.41, and 12.27 MeV with ground-state radiation widths of 5.7, 20.8, and 7.3 eV, respectively. Three weaker transitions, probably M1, are also treated. The apparent excitation of M2 transitions which may possibly be identified with theoretically predicted $2^-$ spin-isospin giant resonances is discussed. The relation of these results to the theory of Kurath as well as to nuclear-model assumptions is also discussed. (auth)

15853 STATES OF $^{25}$Mg EXCITED BY 180° ELECTRON SCATTERING. Fagg, L. W.; Bendel, W. L.; Jones, E. C. Jr.; Kaiser, H. F.; Godlove, T. F. (Naval Research Lab., Washington, D. C.). Phys. Rev.; 187: 1384-8(20 Nov 1969).

Several states in $^{25}$Mg were excited by 180° inelastic electron scattering at bombarding energies of 39 and 56 MeV. A survey was made of the giant-resonance region comprising the upper half of the excitation range 0–27 MeV. In the lower half of this range, studied more intensively, the scattering has caused magnetic dipole transitions to states at 1.60, 5.77, 7.03, 7.81, 10.43, 11.37, and 11.76 MeV. Transition radii and ground-state transition widths are given for these levels. The results are discussed with respect to the collective rotational nature of the nucleus and to the existence of T = 3/2 analog states. (auth)

15854 STUDY OF THE LOW-LYING EXCITED STATES OF $^{29}$Al. II. $^{27}$Al(t,pγ)$^{29}$Al AND $^{30}$Si(t,αγ)$^{29}$Al ANGULAR CORRELATION INVESTIGATION. Jones, A. D. W.; Becker, J. A.; McDonald, R. E. (Lockheed Palo Alto Research Lab., Palo Alto, Calif.). Phys. Rev.; 187: 1388-97(20 Nov 1969).

The low-lying excited states of $^{29}$Al were investigated by measuring γ-ray angular correlations in a collinear geometry. The levels were populated in the $^{27}$Al(t,pγ)$^{29}$Al and $^{30}$Si(t,αγ)$^{29}$Al reactions at triton bombarding energies of 2.8 and 2.5 MeV, respectively. The γ-ray branching ratios for states up to 3.7-MeV excitation energy were obtained. Spin assignments, or limits on the spins, for the first six excited states were deduced on the basis of these data combined with previous results: [$E_x$, $J^\pi$]; 1.40 MeV, $\frac{1}{2}^+$; 1.76 MeV, $(\frac{1}{2})$, $\frac{3}{2}$, $\frac{5}{2}$, $\frac{7}{2}$; 2.23 MeV, $\frac{3}{2}$, $\frac{5}{2}$, $\frac{7}{2}$; 2.88 MeV, $\frac{1}{2}^+$; 3.07 MeV, $(\frac{1}{2}^+)$, $\frac{1}{2}^+$; and 3.19 MeV, $(\frac{3}{2})$, $\frac{1}{2}^{(-)}$, $\frac{1}{2}^{(-)}$, $(\frac{3}{2})$. (auth)

15855 SHELL-MODEL CALCULATION OF THE EVEN-PARITY STATES OF $^{43}$Ca. Pittel, S.; Bayman, B. F. (Univ. of Minnesota, Minneapolis). Phys. Rev.; 187: 1398-1402(20 Nov 1969).

An attempt was made to describe the even-parity states of $^{43}$Ca in terms of the spherical shell model, including all the shell-model states arising from the configuration $[1f_{\frac{7}{2}}]^4[1d_{\frac{3}{2}}\text{-}2s_{\frac{1}{2}}\text{-}1d_{\frac{5}{2}}]^{-1}$. This model gives a good account of the observed energy spectrum. The calculated spectrum of T = 3/2 states is consistent with the level splitting in $^{43}$K. However, these T = 3/2 states are predicted to occur about 2.7 MeV too low in the $^{43}$Ca spectrum. The shell-model wave functions were used to calculate (p,d) and (d,p) spectroscopic factors, log ft values, and M2 hindrance factors. In general, agreement with experiment is good, with the possible exception of the $\frac{1}{2}^+ \rightarrow \frac{5}{2}^-$ M2 hindrance factor. (auth)

15856 STUDY OF THE LEVEL STRUCTURE OF $^{48}$Ti USING THE $^{47}$Ti(n,γ) REACTION. Tenenbaum, J. (Negev Nuclear Research Centre, Beer Sheva, Israel); Moreh, R.; Wand, Y.; Ben-David, G. Phys. Rev.; 187: 1403-9(20 Nov. 1969).

The capture γ-ray spectrum resulting from thermal-neutron capture in $^{47}$Ti was measured using a 30-cm$^3$ Ge(Li) detector and angular-correlation measurements carried out using NaI(Tl) detectors. Some 28 γ lines corresponding to transitions between levels of $^{48}$Ti were observed, and the neutron separation energy of $^{48}$Ti was determined to be 11.630 ± 0.008 MeV. The following assignments of spins and parities for some levels were made: 2.422($1^+$, $2^+$, $3^+$), 3.626($2^+$, $4^+$), 3.794($2^+$, $3^+$, $4^+$), and 4.467($2^+$, $3^+$). The results of a comparison between the measured strengths of exciting the $^{48}$Ti levels in the (n,γ) and (d,p) reactions are discussed. (auth)

15857 STUDY OF THE $^{27}$Al($^3$He,p)$^{29}$Si AND $^{27}$Al($^3$He,pγ) $^{29}$Si REACTIONS. Meyer-Schuetzmeister, L.; Gemmell, D. S.; Holland, R. E.; Kuchnir, F. T.; Ohnuma, H.; Puttaswamy, N. G. (Argonne National Lab., Ill.). Phys. Rev.; 187: 1210-19(20 Nov 1969).

The levels of $^{29}$Si were studied by measuring angular distributions of the $^{27}$Al($^3$He,p)$^{29}$Si reaction. A few states, in particular the level at 8.310 MeV (the analog of the $^{29}$Al ground state), were strongly excited with an orbital angular momentum transfer L = 0 leading to states with J = $\frac{3}{2}^+$, $\frac{5}{2}^+$, and possibly $\frac{1}{2}^+$. The γ decay of some of these levels was studied by p-γ coincidences. They all showed a very similar γ decay, namely, a preference to decay to those few positive-parity states that are also strongly populated in the ($^3$He,p) reaction. From the radiative decay of the 8.310-MeV level and other evidence, it is concluded that the $\frac{5}{2}^+$ state at 4.906 MeV contains the major portion of the antianalog strength. The coincidence data also contained events from $^{27}$Al($^3$He, dγ)$^{28}$Si. Analysis of these results showed that it was consistent with previous measurements. (auth)

15858 PRECISION MEASUREMENTS OF THE $^{182}$Ta GAMMA-RAY SPECTRUM AND THE LEVELS IN $^{182}$W. White, D. H.; Birkett, R. E.; Thomson, T. (Univ. of California, Livermore). Nucl. Instrum. Methods; 77: 261-8(1970).

Measurements have been made on the γ-ray spectrum of $^{182}$Ta using a Ge(Li) detector to determine accurate energies and intensities, primarily of the $^{182}$Ta γ-rays above 1 MeV. The electronics logic was designed to allow comparison of the second-escape peaks of the high energy γ-rays with the low energy full-energy peaks. The resulting γ-ray energies are 1189.045 ± 0.040, 1221.418 ± 0.025, 1230.970 ± 0.030, 1257.470 ± 0.050, 1273.75 ± 0.06, and 1289.17 ± 0.07 keV. Additional runs were taken of the complete spectrum, resulting in precise energy values of the observed transitions. A FORTRAN computer code LEVEL is described which fits the γ-rays to the proposed level scheme by linear least-squares methods, after correcting for nuclear recoil. Final least-squares adjusted values are given for $^{182}$W energy levels and transition energies. (auth)

15859 REMARKS ON THE REGGE-POLE PHENOMENOLOGY IN NUCLEAR SCATTERING. Shastry, C. S. (Louisiana State Univ., Baton Rouge). Phys. Rev.; 187: 1737-8(20 Nov 1969).

Some level parameters of $^{20}$Ne, tentatively assigned on the basis of Regge-pole phenomenology, are compared with the levels determined in a recent experiment by John, Aldridge, and Davis. The connection between some of the phenomenological models for the partial-wave amplitude in nuclear scattering, the corresponding interaction potential, and the Regge-pole theory is discussed. (auth)

15860 ANGULAR DISTRIBUTIONS OF $^{40}$Ca(d,p)$^{41}$Ca AT 2 MeV BOMBARDING ENERGY. Gomez del Campo, J. (Univ. Nacional de Mexico, Mexico City); Rickards, J.; Rapaport, J. Rev. Mex. Fis.; 18: 359-72(1969).

The $^{40}$Ca(d,p)$^{41}$Ca reaction was studied at 2-MeV bombarding energy in order to analyze this reaction within the Coulomb stripping region. Angular distributions of the following levels in $^{41}$Ca were studied: 0, 1, 3, 4 and 5, 6, 10, 11 and 12, 16 and 17, 18 and 19, 20, 21. A DWBA calculation was carried out for levels 0, 1, 3 and 21, and the results were compared to previous work on the same reactions. Spectroscopic factors calculated agree reasonably with earlier work, except for the ground state, where the discrepancy of the order of 100% may be attributed to resonance effects at 2 MeV. Level 21 shows a typical Coulomb stripping pattern, and other distributions show the tendency toward large-angle maximum as the Q-value decreases. (auth)

**15861** BETA–GAMMA–GAMMA CORRELATION IN $^{56}$Mn: A TEST OF TIME-REVERSAL INVARIANCE. Garrell, M.; Frauenfelder, H.; Ganek, D.; Sutton, D. C. (Univ. of Illinois, Urbana). Phys. Rev.; 187: 1410-13(20 Nov 1969).

A test of time-reversal invariance was performed by measuring the imaginary part $|\delta| \sin \eta$ of the mixing ratio $\delta = |\delta| e^{i\eta}$ between E2 and M1 reduced matrix elements through the observation of two $\beta$-$\gamma$-$\gamma$ cascades in $^{56}$Mn. The imaginary part was found to be $(-8.1 \pm 4.8) \times 10^{-3}$ for the 1.81-MeV transition, and $(-7.1 \pm 3.7) \times 10^{-3}$ for the 2.12-MeV transition. In order to eliminate instrumental asymmetries, the difference between the two values was taken, $\Delta(|\delta| \sin \eta) = (1 \pm 6) \times 10^{-3}$. With an average mixing ratio for the two transitions, $\langle|\delta|\rangle = 0.23$, the difference in phases is $\Delta \sin \eta \approx \Delta\eta \approx (0.4 \pm 2.6) \times 10^{-2}$, giving no evidence for time-reversal violation. (auth)

**15862** RADIAL VARIATIONS OF THE CHARGE DENSITIES AND DIRECT ANALYSIS OF ELASTIC SCATTERING OF ELECTRONS ON NUCLEI. Pol, Yu. S. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 10: 771-80(Oct 1969). (In Russian).

A method of direct analysis of elastic scattering of electrons on nuclei is presented in order to extract information about the charge density distribution. The method is to find the coefficients of expansion of the elastic scattering amplitude over a set of analytically given functions, using the $\chi^2$ analysis of the experimental data. On the other hand, the same coefficients determine the expansion of the charge density over the known basis. Thus, one is able to obtain a set of the charge density distributions, satisfying equally well the available experimental data on the elastic scattering of electrons on the $^{40}$Ca nuclei at the electron energy of 250 MeV and on the $^{40}$Ca and $^{48}$Ca nuclei at the energy of 750 MeV. (auth)

**15863** MEAN MULTIPLICITY OF NEUTRON FORMATION DURING COSMIC RAY $\mu$-MESON CAPTURE BY ZINC AND ANTIMONY. Bobodzhanov, I. B.; Gorbachev, S. K.; Leskin, V. A.; Azimov, E. A.; Skurchinskaya, N. E.; Malyshev, Yu. M. (Physical-Technical Inst., Dushanbe, USSR). Dokl. Akad. Nauk Tadzh. SSR; 12: No. 8, 19-20(1969). (In Russian).

Tabulated data on mean multiplicity of neutron formation in each event of $\mu$-meson capture by zinc and antimony nuclei ($\bar{n}_{Zn} = 1.20 \pm 0.02$ and $\bar{n}_{Sb} = 1.49 \pm 0.04$) were in good agreement with published data and once more confirmed the law $\bar{n} = \alpha A^{\frac{1}{3}}$. (R.V.J.)

**15864** PAIRING CORRELATIONS IN NICKEL ISOTOPES. Gunye, M. R.; Khadkikar, S. B. (Tata Inst. of Fundamental Research, Bombay). Phys. Lett.; 30B: 609-11(22 Dec 1969).

The interchange of superconducting character of protons and neutrons in going from $^{60}$Ni to $^{62}$Ni indicates that the conventional approach of assuming the pairing correlations only in neutrons with $f_{\frac{5}{2}}$ shell-closure for protons is not valid. (auth)

**15865** THE $^{26m}$Al PROBLEM. De Wit, P.; van der Leun, C. (Univ., Utrecht). Phys. Lett.; 30B: 639-41(22 Dec 1969).

A precision measurement of the $^{26m}$Al–$^{26}$Mg mass difference brings the anomalously low ft value for the super-allowed pure Fermi transition $^{26m}$Al($\beta^+$)$^{26}$Mg closer to the average of the ft values of six similar $\beta^+$ transitions. The anomaly, however, is still significant. (auth)

## Nuclear Properties and Reactions, A ≥ 90

*Refer also to abstracts 13818, 13887, 14008, 14246, 14492, 15421, 15450, 15474, 15475, 15726, 15791, 15818, 15822, 15833, 15844, 15863, and 16003.*

**15866** (BNL-tr-306) HIGH-ENERGY INTERNAL CONVERSION ELECTRONS EMITTED FROM $^{150}$Sm AND $^{158}$Gd NUCLEI IN THE (n,$\gamma$) REACTION. Panin, Yu. N.; Pelekhov, V. I. (Akademiya Nauk SSSR, Moscow. Institut Atomnoi Energii). Translated by Stephen J. Amoretty (Brookhaven National Lab., Upton, N. Y.), from report IAE-1832. 16p. Dep. CFSTI.

A magnetic spectrometer with a resolution of 0.38% was used to measure the conversion electron spectra from transitions in $^{150}$Sm and $^{158}$Gd following neutron capture in $^{149}$Sm and $^{157}$Gd. Internal conversion coefficients and multipolarities were determined for a large number of transitions with energies above 5 MeV. (J.W.R.)

**15867** (GA–9614) APPLICATION OF PHOTOINDUCED REACTIONS TO NUCLEAR MATERIALS SAFEGUARDS PROBLEMS. Project Summary Report, July 1, 1968–June 30, 1969. Bramblett, R. L.; Ginavin, R. O.; Gozani, T.; Kuil, L.; McMillan, J. I.; Rundquist, D. E. (Gulf General Atomic, Inc., San Diego, Calif.). 29 Jul 1969. Contract AT(04-3)-167. 91p. Dep. CFSTI.

Progress in the development of assay techniques and hardware for quantitative isotopic measurement of special nuclear materials encountered in the nuclear fuel cycle are reported. Some results on prompt and delayed neutron yields and fission-product gamma rays are presented. Some new techniques for the analysis of assay data are described and some results on assays of uranium oxide and uranyl nitrate samples are given. The improvements made in experimental facilities at the electron LINAC are described. (J.W.R.)

**15868** (KFK–966) ACTUAL CONDITION OF THE PHYSICAL KNOWLEDGE OF THE MOST IMPORTANT NUCLEAR REACTOR DATA. Schmidt, J. J. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Neutronenphysik und Reaktortechnik). Apr. 1969. 36p. (In German). (EUR–4172; EANDC(E)–117–U; CONF-690419–2). Dep. CFSTI (U. S. Sales Only).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

A review is presented of the bibliographic data on the alpha decay of $^{239}$Pu, the capture cross sections for $^{238}$U and $^{240}$Pu, the fission cross sections for $^{235}$U, $^{239}$Pu, and $^{240}$Pu, and the $\nu$ factors for $^{239}$Pu and $^{252}$Cf. (70 references) (J.S.R.)

**15869** (LA-tr–69-3(Draft)) DELAYED NEUTRONS AND CHARGE DISTRIBUTION IN FISSION. Maksiutenko, B. P.; Tarasko, M. Z. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Fiziko-Energeticheskii Institut). Translation of report FEI–145. 8p. Dep. CFSTI

The charge distribution in the neutron fission of $^{238}$U was studied by expanding the decay wave. The expansion technique depends on previous data on delayed neutron precursors. The decay curve was measured for 5.5-, 6.0-, and 6.9-MeV incident neutrons using a 512-channel analyzer. The charge distributions obtained show a clear energy dependence. (J.W.R.)

**15870** (NYO–72–190) STUDY OF NEUTRON RESONANCES IN THE SEPARATED ISOTOPES OF ERBIUM AND YTTERBIUM. Liou, Horng-ing (Columbia Univ., New York. Pegram Nuclear Physics Labs.). [1968]. Contract AT(30-1)-Gen-72. 160p. Dep. CFSTI.

Thesis.

The results of neutron time-of-flight measurements of Yb and Er stable isotope resonance parameters are presented. Neutron widths for 127 observed levels of Yb and 233 levels of Er are obtained, up to a few hundred eV for odd isotopes, and a few keV for even isotopes. In some cases, resonance radiation widths and J values are deduced. The values for s-wave strength function for various Yb and Er isotopes are $(1.49 \pm 0.40) \times 10^{-4}$ ($^{171}$Yb), $(0.99 \pm 0.36) \times 10^{-4}$ ($^{172}$Yb), $(1.64 \pm 0.45) \times 10^{-4}$ ($^{173}$Yb), $(0.89 \pm 0.43) \times 10^{-4}$ ($^{174}$Yb), $(1.85 \pm 0.84) \times 10^{-4}$ ($^{176}$Yb), $(1.70 \pm 0.45) \times 10^{-4}$ ($^{166}$Er), $(1.95 \pm 0.32) \times 10^{-4}$ ($^{167}$Er), $(1.43 \pm 0.40) \times 10^{-4}$ ($^{168}$Er), and $(1.44 \pm 0.48) \times 10^{-4}$ ($^{170}$Er). Detailed comparisons of the observed statistical aspects of the reduced neutron widths and adjacent level spacings were made with the Porter–Thomas distribution and the Wigner repulsion theory, respectively. The detection schemes for the flat detector transmission and the self-indication measurements, the theory, and the methods of analysis are discussed. (auth)

**15871** (ORNL–TM–2797) AN EVALUATION AND COMPILATION OF THE FISSION AND CAPTURE CROSS SECTIONS OF $^{239}$Pu IN THE ENERGY RANGE 25 keV TO 15 MeV. Greene, N. M.; Lucius, J. L. (Union Carbide Corp., Oak Ridge, Tenn. Computing Technology Center); Craven, C. W. Jr. (Oak Ridge National Lab., Tenn.). Jan 1970. Contract W-7405-eng-26. 48p. Dep. CFSTI.

An evaluation and compilation of the fission and capture cross sections of $^{239}$Pu in the energy range 25 keV to 15 MeV was made. The evaluation was a part of the cooperative effort of the Fissile and Fertile Task Force of the Cross Section Evaluation Working Group to improve and extend the first iterate ENDF/B data. The evaluation was performed by making a weighted least squares fit of the available experimental data. The parameters chosen for the analysis were the ratio of the fission cross section of $^{239}$Pu to that of $^{235}$U and the capture-to-fission ratio (alpha) of $^{239}$Pu. The Task Force had previously agreed on a reference set of fission cross sections for $^{235}$U. The input data for the fit of the fission ratio included values and experimental uncertainties reported for some 24 experiments. Where this parameter was not directly measured, it was inferred, if possible, from measurements performed in the same experiment for the fission cross sections of $^{239}$Pu and $^{235}$U. In some instances, a ratio of ratio measurements was used. Where only the fission cross section for $^{239}$Pu was measured, the fission

ratio was calculated using the reference set of $^{235}U$ data. The fission ratio data thus obtained were fitted by high-order polynomials using a weighted least-squares technique, and the reference set of $^{235}U$ data was used to generate tables of $^{239}Pu$ data. Alpha data from five experimentalists were fitted using the least-squares technique noted previously. No data obtained via integral measurements were included in either analysis. Tabulations and plots of the results are included. (auth)

15872 (ORNL-RSIC-27) A REVIEW OF MULTIGROUP NUCLEAR CROSS SECTION PREPARATION THEORY, TECHNIQUES, AND COMPUTER CODES. Trubey, D. K.; Gurney, Jane (comps.) (Oak Ridge National Lab., Tenn.). Jan 1970. Contract W-7405-eng-26. 185p. Dep. CFSTI.

Summaries are presented of papers given at a seminar-workshop on "Multigroup Cross Section Preparation—Theory, Techniques, and Computer Codes" held at Oak Ridge, Tennessee, October 1—3, 1969. The papers, in their review of the state-of-the-art, show that great progress has recently been made in coping with what is the most important problem in radiation transport—cross sections. The papers describe the large number of computer codes, techniques, and data files now available for cross section preparation for use in transport codes. The recently developed codes SUPERTOG, XSDRN, and DOT-II have been placed with the Radiation Shielding Information Center for routine dissemination. (auth)

15873 THE MEASUREMENT OF MAGNETIC MOMENTS OF EXCITED STATES IN PALLADIUM, TUNGSTEN, AND THULIUM NUCLEI. Kaufmann, Elton Neil. Pasadena, Calif.; California Inst. of Tech. (1969). 130p.
Thesis.

The perturbed gamma-gamma angular correlation technique was used to measure the magnetic moments of several nuclear excited states. The magnetic moment of the second excited $2^+$ state in $^{106}Pd$ was measured to be $\mu = 0.74 \pm 0.14$ nm, in good agreement with the interpretation of that state as a two-phonon quadrupole vibration about spherical equilibrium. The magnetic moment of the two-quasiparticle $2^-$ state at 1289 keV in $^{182}W$ was measured to be $\mu = 1.04 \pm 0.24$ nm, in poor agreement with the predictions of the "strong-coupling" approximation. The probable origin of the discrepancy is discussed. The following magnetic moments in odd-mass thulium nuclei were measured: the $^5/_2^+$ level at 118.2 keV in $^{169}Tm$ with $\mu = 0.79 \pm 0.08$ nm; the $^7/_2^+$ level at 138.9 keV in $^{169}Tm$ with $\mu = 1.33 \pm 0.07$ nm; the $^5/_2^+$ level at 116.7 keV in $^{171}Tm$ with $\mu = 0.81 \pm 0.37$ nm; and the $^7/_2^+$ level at 129.1 keV in $^{171}Tm$ with $\mu = 1.44 \pm 0.14$ nm. In addition, the multipole mixing amplitude for the 109.8-keV transition in $^{169}Tm$ was measured to be $\delta(E2/M1) = -0.15 \pm 0.02$, and the crossover-to-cascade transition intensity ratios for the $^5/_2^+$ (116.7 keV and $^7/_2^+$ (129.1 keV) states in $^{171}Tm$ were measured to be $I_\gamma(^5/_2 \rightarrow {}^1/_2)/I_\gamma(^5/_2 \rightarrow {}^3/_2) = 0.115 \pm 0.005$ and $I_{tot}(^7/_2 \rightarrow {}^3/_2)/I_{tot}(^7/_2 \rightarrow {}^1/_2) = 3.22 \pm 0.58$, respectively. The results of the measurement in the thulium nuclei were used in conjunction with other data to determine the parameters in the rotational model description of the nuclei. The magnetic parameters are interpreted in terms of transverse and longitudinal spin polarization effects, where only qualitative agreement with theory is found. A correction to the rotational model predictions of electric quadrupole transition rates is also discussed. (Diss. Abstr.)

15874 THE NUCLEAR SPINS AND MOMENTS OF $^{119}Sb$ AND $^{115}Sb$. Rogers, Edward Hallock Jr. Princeton, N. J.; Princeton Univ. (1969). 108p.
Thesis.

The hyperfine structure (HFS) of 38-hr $^{119}Sb$ and $^{115}Sb$ was measured by the atomic beam magnetic resonance method. The isotopes were produced by the $^{119}Sn(p,n)^{119}Sb$ and the $^{116}Sn(p,2n)^{115}Sb$ reactions in the Princeton University cyclotron with isotopically enriched targets. The HFS was studied in the off-line hybrid focussing beam apparatus. The values of the spins, HFS constants, and moments were obtained. (Diss. Abstr.)

15875 STUDIES OF THE COLLECTIVE STATES IN $^{152}Gd$, $^{152}Sm$, AND $^{154}Gd$. Riedinger, Leo Louis Jr. Nashville; Vanderbilt Univ. (1969). 236p.
Thesis.

The gamma rays emitted in the radioactive decays of 12.4-year $^{153}Eu$ and 16-year $^{154}Eu$ were observed in order to study the properties of $^{152}Sm$, $^{152}Gd$, and $^{154}Gd$, nuclei in the transitional region between spherical and deformed shapes. Energies, intensities, and placements of the observed gamma rays were determined from singles and coincidence experiments involving Ge(Li) and NaI detectors. Detailed comparisons of the measured properties of the collective states in these nuclei to the predictions of the various collective theories were made. Preliminary studies of the gamma rays emitted in the 46-minute decay of $^{156}Eu$ were conducted. Energies and relative intensities were assigned to these gamma rays. (Diss. Abstr.)

15876 CORRELATION AND ANALYSIS OF THE MASS, ENERGY AND RADIATION EMISSION CHARACTERISTICS OF FISSION FRAGMENTS RESULTING FROM THERMAL NEUTRON CAPTURE BY $^{233}U$, $^{235}U$, AND $^{239}Pu$. Rodgers, Reginald Charles. Washington, D. C.; The Catholic Univ. of America (1969). 181p.
Thesis.

Utilizing semi-empirical mass formulations and the measured prompt fission fragment mass yields, kinetic energies, and neutron yields, improved models have been formulated to determine the charge and deformation energy of the fission fragments, their prompt neutron yields, and the fission product yield resulting from thermal neutron capture by $^{233}U$, $^{235}U$ and $^{239}Pu$. In this treatment, two appropriately weighted charge numbers are determined for each fragment, each fragment pair is analyzed separately, and the total neutron yield and energy spectrum are determined by suitably averaging the results for each fragment pair. The models are interlinked in a phenomenological fashion and are iterated upon to obtain agreement with known experimental information. A comparative evaluation of the recent semi-empirical mass formulas of Wing—Fong, Myers—Swiatecki, and Seeger (1967) was made as to their prediction of measured mass values. The formulas were also evaluated as to the relative acceptability of the trends obtained using them in calculations of the variation of the fission Q-value and the most probable charge with the fragment mass. Seeger's (1967) mass formula was judged the most acceptable for this investigation. The most probable charges of the initial fission fragments are computed based on the assumption that the Q-value for fission is a maximum. A different type of charge distribution about the most probable value is postulated. This distribution favors the charge numbers having the larger fission Q-values. For the determination of the division of kinetic and deformation energy among the individual fragments at scission, a model of suitably enlarged, spherical, uniformly charged fragments is formulated to fit the experimental fragment total kinetic energy. The computed enlargement of individual fragments is taken as a measure of the increase in surface energy. This deformation energy is considered as the initial excitation energy of the fragments in an improved neutron evaporation model which predicts the number of neutrons, their individual energy spectra and the total amount of gamma energy emitted by individual fragments. Consideration is given to the finite magnitude of the upper limit of the evaporation spectrum and a cut-off condition for neutron emission is devised. The initial fission product mass yield curve compared favorably with mass spectrometer and radiochemical results. The yields of some experimentally identified, delayed neutron precursors are estimated. This analysis predicts 2.44, 2.42, and 3.09 prompt neutrons per fission from $^{233}U$, $^{235}U$, and $^{239}Pu$, and a total prompt gamma energy per fission of 7.76, 7.65, and 6.71 MeV, respectively; these results are in good agreement with measured values. The charge distribution, kinetic energy, and deformation energy models were generalized to predict the corresponding fission fragment characteristics for the spontaneous fission of $^{252}Cf$. The predictions of the charge distribution and kinetic energy models were within 5% of experimental data. The deformation energies of individual fragments were predicted with an estimated accuracy of 20 to 30%. (Diss. Abstr.)

15877 MASS AND CHARGE DISTRIBUTIONS IN THE FISSION OF $^{249}Cf$ WITH THERMAL NEUTRONS. Flynn, K. F. (Eidgenoessische Technische Hochschule, Wuerenlingen, Switzerland); von Gunter, H. R. Helv. Chim. Acta: 52: 2216-21(10 Dec 1969). (In German).

The distribution of mass and charge in the thermal-neutron-induced fission of $^{249}Cf$ has been investigated by radiochemical determination of the fission yields of 25 mass chains and one shielded nuclide (independent yield). The mass distribution is asymmetric, as in all known cases of low-energy fission. The fission yield data indicate a value of $6 \pm 1.5$ for $\bar{\nu}$, the average number of neutrons emitted per fission. The division of nuclear charge, as indicated by the independent yield of $^{136}Cs$, is consistent with the equal charge displacement hypothesis characteristic of low-energy fission. (auth)

15878 DECAY STUDIES OF Au ISOTOPES IN THE MASS NUMBER REGION 186–189. Johansson, A.; Svahn, B.; Nyman, B.; Antman, S. (Univ. of Uppsala). Z. Phys.: 230: 291-308(1970).

Internal conversion electrons and gamma-rays emitted in the decays of the neutron deficient gold isotopes with mass numbers 186—189 were studied with a double focussing beta-ray spectrometer and a Ge(Li) detector. Multipolarities for the strongest transitions were deduced. A revised level scheme for $^{189}Pt$ is

proposed. The half-lives of $^{196}$Au, $^{198}$Au and $^{199}$Au are found to be (10.7 ± 0.5), (9.0 ± 0.4) and (28.6 ± 1.0) minutes respectively. (auth)

15879 THE DECAYS OF $^{102g}$Rh, $^{102m}$Rh, AND $^{102m}$Tc. Hussein, H. A. M. (Univ., Goettingen, Ger.). Z. Phys.; 230: 358-70(1970). (In German).

The decays of the 206 day-$^{102g}$Rh, 2.9 year-$^{102m}$Rh and 4.35 min-$^{102m}$Tc have been investigated using several sizes of Ge(Li)-counters. From the analysis of gamma spectra from several $^{102}$Rh-sources, measured over a period of 2.2 years, the gamma rays associated with each activity were identified. Energies and relative gamma intensities of 71 transitions have been determined. 22 transitions are assigned to the decay of 206 day-$^{102g}$Rh, 16 to 2.9 year-$^{102m}$Rh and 33, twenty five unreported, to 4.35 min-$^{102m}$Tc. All except one transition are placed in a level scheme of $^{102}$Ru. (auth)

15880 THE REACTION $^{154}$Sm(p,t)$^{152}$Sm AND FURTHER EVIDENCE FOR SHAPE COEXISTENCE IN $^{152}$Sm. McLatchie, W. (Oxford Univ. Queen's Univ., Kingston, Can.); Kitching, J. E.; Darcey, W. Phys. Lett.; 30B: 529-30(8 Dec 1969).

Triton angular distributions are presented for the reaction $^{154}$Sm(p,t)$^{152}$Sm. The reaction fails to excite to a detectable degree the proposed "spherical" $0^+$ state at 1091 keV in $^{152}$Sm. (auth)

15881 MAGNETIC AND QUADRUPOLE MOMENTS OF THE 86.5 keV EXCITED STATE OF $^{155}$Gd. Bauminger, E. R.; Froindlich, D.; Mustachi, A.; Nowik, I.; Ofer, S.; Samuelov, S. (Hebrew Univ., Jerusalem). Phys. Lett.; 30B: 531-2(8 Dec 1969).

Recoilless absorption studies of several gadolinium compounds yield the following nuclear parameters for the 86.5 keV level of $^{155}$Gd: I(86.5) = 5/2; g(86.5)/g(0) = 1.22 ± 0.01 and Q(86.5)/Q(0) = 0.12 ± 0.01. These parameters can be explained only by assuming strong band mixing. (auth)

15882 LEVELS IN $^{140,142,144}$Nd AND A SEARCH FOR PAIRING VIBRATIONS AT N = 82 WITH THE (p,t) REACTION. Ball, J. B.; Auble, R. L.; Rapaport, J.; Fulmer, C. B. (Oak Ridge National Lab., Tenn.). Phys. Lett.; 30B: 533-5(8 Dec 1969).

The $^{142,144,146}$Nd(p,t) reactions were studied with 31-MeV protons. A pair-vibrational like state is observed in the $^{144}$Nd(p,t) reaction but shifted in energy and with less intensity than expected. Although no such state is seen in the $^{146}$Nd(p,t) reaction, the same L = 0 intensity to excited states is observed to be distributed among a number of $0^+$ levels. (auth)

15883 SPACING OF CLASS II LEVELS IN THE FISSION OF $^{240}$Pu. Sood, D. K.; Sarma, N. (Bhabha Atomic Research Centre, Bombay). Phys. Lett.; 30B: 523-5(8 Dec 1969).

A modified correlation analysis of high resolution fission cross sections is suggested which would yield more reliable estimates of the spacing, $\bar{D}_{II}$ of the class II levels. Subsequent analysis of the reaction $^{239}$Pu(n,f) gives the value of $\bar{D}_{II}$ as 225 ± 25 eV for the nucleus $^{240}$Pu. (auth)

15884 ANALYSIS OF NEUTRON SCATTERING DATA ON $^{93}$Nb. Sharma H. C.; Nath, N. (Banaras Hindu Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 12-18(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The level scheme of $^{93}$Nb resulting from neutron inelastic scattering studies is discussed. Methods for choosing the potential parameters used in theoretical studies are analyzed. The importance of width fluctuation effects in optical-model analyses is pointed out. (J.W.R.)

15885 LEVEL SCHEME OF $^{109}$Cd. Baliga, B. B.; Chatterjee, M. B. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 77-81(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The gamma spectrum for the decay of $^{109}$In was studied using a Ge(Li) detector. The γ rays observed were associated with possible levels and transitions in $^{109}$Cd. (J.W.R.)

15886 NEUTRON CAPTURE CROSS-SECTION OF $^{115}$In AT 24 keV. Chaubey, A. K.; Hasan, S. S.; Sehgal, M. L. (Aligarh Muslim Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 88-91(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The cross section for the $^{115}$In(n,γ)$^{116m}$In reaction at 24 keV was measured. The cross section was compared with another recent measurement. The reason for the large discrepancy is analyzed. (J.W.R.)

15887 FRAGMENT MASS-DISTRIBUTIONS IN PHOTOFISSION AND NEUTRON INDUCED FISSION OF $^{238}$U. Iyengar, K. N.; Rangarajan, R. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 110-15(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210(Vol.2).

The mass distributions of fragments from the thermal fission of $^{235}$U, the photofission of $^{238}$U, and the 14-MeV neutron fission of $^{238}$U were measured using solid-state track detectors. In addition, the $^{238}$U photofission was studied using a nuclear emulsion. The resolution obtained did not permit reliable conclusions to be drawn about the differences in the peak to valley ratios for the $^{238}$U photofission and neutron-induced fission. (J.W.R.)

15888 K X-RAY YIELDS OF FRAGMENTS OF SPECIFIED NUCLEAR CHARGES. Kapoor, S. S.; Kataria, S. K.; Murthy, S. R. S.; Rama Rao, P. N. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 116-21(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

An x-ray spectrometer of 800 eV resolution was used to study the x-ray spectra from the fragments of $^{235}$U thermal neutron fission. The K x-ray yield as a function of Z was determined. The observed behavior of the yield as a function of Z is similar to that observed earlier as a function of mass. (J.W.R.)

15889 ENERGY DISTRIBUTIONS IN NEUTRON INDUCED PROMPT FISSION FRAGMENTS. Sarkar, Ratna; Chatterjee, Aparesh (Calcutta Univ. Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 122-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The distributions of excitation energies and kinetic energies for the prompt fission fragments from the thermal neutron fission of $^{232}$Th, $^{235}$U, $^{238}$U, and $^{239}$Pu were estimated as a function of mass. The excitation energies were estimated in the framework of a renormalized Fermi surface model in which the ground state is corrected for single particle effects and collective interactions. (J.W.R.)

15890 REACTIONS (n,2n), (n,α), AND (n,p) IN RARE-EARTH ISOTOPES AND THE STATISTICAL MODEL. Rama Prasad, P.; Rama Rao, J.; Kondaiah, E. (Andhra Univ., Waltair, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 128-32 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Cross sections were measured for (n,2n) reactions on $^{147}$Nd, $^{144}$Sm, $^{149}$Nd, $^{153}$Eu, $^{159}$Tb, $^{160}$Gd, and $^{162}$Er; (n,α) reactions on $^{144}$Nd, $^{151}$Eu, $^{156}$Gd, $^{158}$Gd, and $^{165}$Ho; and (n,p) reactions on $^{149}$Sm and $^{159}$Tb at 14 MeV using an NaI(Tl) scintillation spectrometer. The data are compared with values from the literature. (J.W.R.)

15891 ANGULAR DISTRIBUTION OF FISSION FRAGMENTS IN THE NEUTRON INDUCED FISSION OF $^{235}$U NEAR THRESHOLD. Nadkarni, D. M.; Kapoor, S. S.; Rama Rao, P. N. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 133-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The angular distributions were measured at 0 and 90° for the reaction $^{235}$U(n,f) for neutron energies up to 1.5 MeV using solid-state detectors. The results indicate that the pairing energy gap at saddle-point deformation is larger than at stable nuclear deformation. (J.W.R.)

15892 ANGULAR CORRELATION ON 325-177 keV CASCADE IN $^{131}$Xe. Brahmananda Rao, P.; Lakshminarayana, V. (Andhra Univ., Waltair, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 162-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The 325-177 keV cascade in $^{131}$Xe following the decay of $^{131}$I was studied using the sum-coincidence method. Angular correlation coefficients were determined. Spin assignments are suggested for the 341- and 667-keV levels in $^{131}$Xe. (J.W.R.)

15893 STRUCTURE OF THE 343 keV STATE IN $^{111}$Cd. Ramamurthy, V. V.; Rama Rao, M. T.; Lakshminarayana, V. (Andhra Univ., Waltair, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 166-9(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The mean life of the 343-keV state in $^{111}$Cd was measured using the delayed coincidence method with a $^{111}$Ag source. An E2 enhancement and a large M1 hindrance for the 343-keV transition are compared with predictions from previous calculations. (J.W.R.)

15894 URANIUM QUADRUPOLE MOMENT BASED ON A DUAL CORE FISSIONABLE MODEL. Narayana, K. L. (Shivaji Univ., Kolhapur, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 170-4(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

An attempt is made to understand the phenomenon of fission in terms of shell structure. A dual core model for uranium with one core containing 50 protons and 82 neutrons and another containing 40 protons and 50 neutrons with the remaining neutrons and the two protons moving in an axially symmetric field is proposed. The electric quadrupole moments are calculated for several nucleon orbitals. (J.W.R.)

15895 BETA DECAYS OF $^{147}$Nd AND $^{140}$La. Nagarajan, T.; Ravindranath, M.; Reddy, K. Venkata (Andhra Univ., Waltair, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 175-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The shape factors for the 803-keV $\beta$ group of $^{147}$Nd and the 2164-keV $\beta$ group of $^{140}$La were determined using a Siegbahn-Slatis well-type spectrometer. The values obtained are compared with shell-model calculations. (J.W.R.)

15896 GAMMA-GAMMA-GAMMA-DIRECTIONAL CORRELATIONS IN $^{134}$Ba. Pande, U. S.; Singh, B. P. (Univ. of Roorkee, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 178-82(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Triple gamma angular correlations in $^{134}$Ba following the decay of $^{134}$Cs were measured using NaI(Tl) detectors. The measurements permit unambiguous spin assignments to be made for several levels in $^{134}$Ba. In addition, the multipole mixtures in the transitions were determined. (J.W.R.)

15897 DECAY OF $^{131}$Ba. Mangal, P. C.; Bawa, Parveen; Trehan, P. N. (Panjab Univ., Chandigarh, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 188-92(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Slow-fast coincidence and sum-coincidence studies on the electron-capture decay of $^{131}$Ba using NaI(Tl) crystals are given. Gamma-gamma angular correlations were measured for the 923-124, 831-216, and 496-124 keV cascades. The data were fitted into the level scheme for $^{131}$Cs. The angular correlations permitted multipole mixing ratios for the transitions to be determined. (J.W.R.)

15898 DECAY OF $^{103}$Ru. Sud, S. P.; Arora, B. K.; Trehan, P. N. (Panjab Univ., Chandigarh, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 234-8(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

NaI(Tl) crystals were used to measure the $\gamma$ singles, slow-fast coincidence, and sum-coincidence spectra in the decay of $^{103}$Ru. The k-conversion coefficient for the 53-keV transition was determined. The data were fitted to the $^{103}$Rh level scheme. (J.W.R.)

15899 DECAY OF $^{96m}$Tc AND THE EXCITED LEVELS OF $^{96}$Mo. Basu, S. K.; Patro, A. P. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 257-9(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The gamma spectra accompanying the decay of $^{96m}$Tc were measured using a high-resolution Ge(Li) detector. The observed lines were fitted into the $^{96}$Me level scheme. (J.W.R.)

15900 NATURE OF THE 268 keV LEVEL IN $^{197}$Au. Prasad, K. G.; Sharma, R. P. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 260-3(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

It has been suggested the observed E2 enhancement of the 191-keV transition in $^{197}$Au is evidence for a large deformation of the 268-keV level. Since there is a large variation in the B(E2) value of the 268-keV level and the k-conversion coefficient of the 191-keV transition, these two quantities were remeasured. An enhancement of 7 was determined for the E2 part of the 191-keV transition. This is not large enough to support the hypothesis of a deformed 268-keV level in $^{197}$Au. (J.W.R.)

15901 GAMMA GAMMA ANGULAR CORRELATION IN $^{110}$Cd. Prasad, Rajendra; Sehgal, M. L. (Aligarh Muslim Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 278-83(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Gamma coincidence spectra and angular correlations were measured for the decay of $^{110m}$Ag using NaI(Tl) crystals in a slow-fast coincidence circuit. A number of levels in $^{110}$Cd were verified and a spin of $4^+$ was assigned to the 2220-keV level. (J.W.R.)

15902 DECAY OF 1.6 min $^{185m}$W. Pathak, B. P.; Gujrathi, S. C.; Mukherjee, S. K. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 293-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The $\gamma$ ray singles spectra from the decay of $^{185m}$W were measured using a Ge(Li) detector, and $\gamma-\gamma$ coincidence spectra were measured using NaI(Tl) detectors. The level scheme for $^{185}$W was determined and compared with nuclear model descriptions. (J.W.R.)

15903 FERMI MATRIX ELEMENTS IN THE BETA DECAYS OF $^{59}$Fe. Mitra, S. K.; Padhi, H. C. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 303-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The Fermi matrix elements for the 273- and 475-keV beta transitions in the decay of $^{59}$Fe were measured using the $\beta-\gamma$ circular polarization correlation method. The matrix elements were then used to determine the isospin impurities. The measured asymmetry coefficients are in agreement with other measurements. (J.W.R.)

15904 g FACTORS OF THE 321 AND 462 keV LEVELS OF $^{125}$Te. Singh, Vikram; Tandon, P. N.; Devare, S. H.; Devare, H. G. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 306-9(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The g-factors for the 321- and 462-keV states of $^{125}$Te were measured using the integral reversed field method of the perturbed angular correlation technique. The large half-life of the 321-keV state permitted use of an external magnetic field. The large hyperfine fields present at a Te site in Fe were used for the 462-keV state. (J.W.R.)

15905 FAST NEUTRON CROSS SECTIONS OF HAFNIUM, GADOLINIUM, AND SAMARIUM. Sherwood, G. L.; Smith, A. B.; Whalen, J. F. (Argonne National Lab., Ill.). Nucl. Sci. Eng.; 39: 67-80(Jan 1970).

Elastic- and inelastic-neutron-scattering cross sections of elemental Hf, Gd, and Sm were measured at incident neutron energies of 0.3 to 1.5 MeV. The experimental resolution was sufficient to reasonably resolve elastic and inelastic processes and define individual inelastic cross sections for the most appreciably excited states. The total neutron cross sections were determined up to 1.5 MeV with resolutions of $\gtrsim$2.5 keV. Within the precisions of the measurements all observed cross sections were relatively smooth functions of energy. The experimental results were compared with those obtained from calculations based upon both spherical and deformed optical potentials and statistical theory inclusive of fluctuation corrections. The calculated results were descriptive of measured total, elastic scattering and, to a lesser extent, inelastic scattering cross sections. Experimental and calculated results were compared with previously reported measured values and with the contents of several evaluated neutron-data sets employed in reactor design. (auth)

15906 GAMMA-RAY SPECTRA OF THE PRODUCTS OF THERMAL-NEUTRON FISSION OF $^{235}$U AT SELECTED TIMES AFTER FISSION. Bunney, L. R.; Sam, D. (Naval Radiological Defense Lab., San Francisco). Nucl. Sci. Eng.; 39: 81-91 (Jan 1970).

Experimental measurements of the $\gamma$-ray spectra emitted by the products of thermal-neutron fission of $^{235}$U were made at nine se-

lected times (¼, ½, 1, 2, 5, 10, 24, 48, and 72 h) after fission. A calibrated and highly collimated 5- × 5-in. NaI(Tl) detector was used. The 100-energy-bin γ-ray spectra were unfolded from the pulse-height distributions by means of an iterative method. Extensive use was made of machine computation. The number of fissions in each sample was determined radiochemically. Significant differences between this work and calculated spectra were found. At the earlier times the experimental photon emission rate is higher than the calculated rate by as much as 40%. At later times the experimental rate is 20% lower than the calculated rate. Surprisingly large differences (as much as 33%) were found between the photon emission rates of products of fission by slow neutrons and by fast neutrons. (auth)

15907 DETERMINATION OF FISSION DENSITY IN $^{235}U$ AND IMPLICATIONS FROM ITS MASS DISTRIBUTION. Popa, Petru; DeCoster, Marcel; Van Assche, Pieter H. M. (SCK-CEN, Mol, Belg.). Nucl. Sci. Eng.; 39: 50-5(Jan 1970).

The absolute ratio of fission densities due to thermal- and epicadmium-neutron fluxes was measured by solid-state track detectors. A systematic deviation from this absolute ratio is observed when measuring γ activities of fission products. From a careful analysis of the gamma spectra with a Ge(Li) detector, it was concluded that this systematic deviation is due to important changes in the mass distribution of fission products produced by epicadmium neutrons, with respect to the well-known mass distribution for thermal neutrons. (auth)

15908 STATISTICAL CONSTRUCTION OF RESONANCE STRUCTURE IN THE UNRESOLVED RESONANCE REGION. Ohnishi, Tadahiro (Hitachi Lts., Kawasaki, Japan); Ueda, Yasuyuki. J. Nucl. Sci. Technol. (Tokyo); 6: 715-17(Dec 1969).

A method for the generation of artificial resonances for use in neutronics calculations is described. The foundation of the method is the fitting of the resonance structure to experimental data on the energy structure of cross sections in the unresolved resonance region. Some preliminary results for $^{239}Pu$ in the energy range 0.275 to 2.035 keV are presented. (J.W.R.)

15909 DECAYS OF $^{95}Zr$ AND $^{95}Nb$. Brahmavar, S. M.; Hamilton, J. H. (Vanderbilt Univ., Nashville). Phys. Rev.; 187: 1487-91(20 Nov 1969).

The $^{95}Zr \rightarrow {}^{95}Nb \rightarrow {}^{95}Mo$ decay chain was investigated with a high-resolution 30-cm³ Ge(Li) detector and a Si(Li) detector and a 4096-channel analyzer. The following γ rays were observed for a $^{95}Zr$–$^{95}Nb$ equilibrium source (energies in keV and intensities in parentheses): 234.70 ± 0.14 (0.34 ± 0.03), 724.23 ± 0.04 (81.0 ± 1.0), 756.74 ± 0.04 (100), and 765.83 ± 0.04 (218.0 ± 3.0). β feedings of (1.0 ± 0.1)%, (44.2 ± 0.5)%, and (54.6 ± 0.5)% were calculated for the 234.7-, 724.2-, and 756.7-keV levels in $^{95}Nb$. The K-conversion coefficients for the 724.2-, 756.7-, and 765.8-keV γ rays were measured by the NPG method to be (1.56 ± 0.14) × $10^{-3}$, (1.45 ± 0.15) × $10^{-3}$, and (1.32 ± 0.13) × $10^{-3}$, respectively. (auth)

15910 $^{208}Pb(^3He,\alpha)^{207}Pb$ REACTION AT 47.5 MeV. Satchler, G. R. (Oak Ridge National Lab., Tenn.); Parkinson, W. C.; Hendrie, D. L. Phys. Rev.; 187: 1491-6(20 Nov 1969).

The absolute differential cross sections for the six lowest-lying levels of $^{207}Pb$ excited by the $^{208}Pb(^3He,\alpha)^{207}Pb$ reaction were measured for 47.5-MeV incident energy. A distorted-wave analysis yields relative spectroscopic factors which are apparently not in good agreement with those obtained from the (d,t) reaction. Transitions with large l transfer are strongly favored over those with small l. Further, the theoretical predictions for small l are sensitive to the treatment of the contributions from the nuclear interior. The precise value of l is not easily determined from angular-distribution measurements at this bombarding energy. (auth)

15911 DECAY OF $^{203}Hg$: L-SUBSHELL FLUORESCENCE YIELDS AND COSTER–KRONIG TRANSITION PROBABILITIES OF Tl. Wood, R. E.; Palms, J. M.; Rao, P. Venugopala (Emory Univ., Atlanta). Phys. Rev.; 187: 1497-1503(20 Nov 1969).

Thallium L-subshell fluorescence yields and Coster-Kronig transition probabilities are determined by observing L x rays in coincidence with $K\alpha_1$ x rays, $K\alpha_2$ x rays, and L-conversion electrons following the β decay of $^{203}Hg$ to the 279-keV level in $^{203}Tl$. High-resolution Si(Li) and Ge(Li) detectors are employed. The following results are obtained: $\nu_1 = 0.280 \pm 0.010$, $\omega_1 = 0.07 \pm 0.02$, $f_{12} = 0.14 \pm 0.03$, $f_{13} \pm 0.56 \pm 0.05$, $\nu_2 = 0.371 \pm 0.010$, $\omega_2 = 0.319 \pm 0.010$, $f_{23} = 0.169 \pm 0.010$, and $\omega_3 = 0.306 \pm 0.010$. Angular correlations between $K\alpha_1$ and L x rays are studied and the following values are obtained for $A_2$ in the relation $W(\theta) = 1 + A_2P_2(\cos\theta)$: 0.05 ± 0.03 for Lα x rays, 0.26 ± 0.05 for Ll x rays. No angular correlation is found between $K\alpha_1$ and Lβ x rays. The L–x-ray emission rates from $L_2$- and $L_3$-subshell vacancies are compared with the recent calculations by Scofield. (auth)

15912 COMPLEX MEASUREMENT OF THE THALLIUM-ISOTOPE MASSES. Demirkhanov, R. A.; Dorokhov, V. V. Yadern. Fiz.; 10: 433-9(Sep 1969). (In Russian).

Mass-spectrographic measurements of the masses of $^{203}Tl$ and $^{205}Tl$ isotopes are fulfilled with the test of self–consistency of the results. Organic matters, masses of the Hg isotopes, chlorides of Er and Tu are used as standards. Measuring every doublet, the mass difference $^{205}Tl - {}^{203}Tl$ was determined. 26 doublets are measured. The Tl masses are measured with the error $\Delta M/M = 7 \cdot 10^{-8}$. (auth)

15913 ON NONPERTURBED ANGULAR CORRELATIONS OF γ QUANTA FROM THE CASCADE 459.7 TO 27.7 keV IN $^{129}I$ NUCLEUS. Makaryunene, E. K.; Makaryunene, K. V. (Inst. of Physics and Mathematics, Vilnyus, USSR). Yadern. Fiz.; 10: 440-4(Sep 1969). (In Russian).

Angular correlation of γ rays from the cascade 459.7–27.7 keV in $^{129}I$ was investigated with various sources. The maximal anisotropy is in the correlation measured with liquid tellurium sources in $HNO_3$. It has the form $W(\theta) = 1 + (0,056 \pm 0,018)P_2(\cos\theta) - (0.029 \pm 0.035)P_4(\cos\theta)$. The problem of spin of the 487.4-keV level in $^{129}I$ is discussed. (auth)

15914 ISOMER RATIOS OF $^{134}Cs$ FORMED IN THE FISSION OF $^{233}U$ AND $^{235}U$ BY PROTONS OF ENERGIES 20 TO 85 MeV. Saha, G. B.; Tomita, I.; Yaffe, L. (McGill Univ., Montreal). J. Inorg. Nucl. Chem.; 31: 3731-7(Dec 1969).

The isomer ratios of $^{134}Cs$ formed in the fission of $^{233}U$ and $^{235}U$ by protons of energies 20 to 85 MeV were determined experimentally. Calculations were made for these isomer ratios on the basis of a statistical theory of the spin distribution of the primary fragments. The root-mean-square angular momentum, $\sqrt{J^2}$, characterizing the spin distribution of the primary fragments, varies between 12ħ at 20 to 30 MeV and 18ħ at 85 MeV in $^{233}U$ fission, whereas it is about 16ħ in $^{238}U$ fission throughout this energy region. The relatively large values of $\sqrt{J^2}$ indicates that a fraction of the angular momentum of the fissioning nucleus appears as the intrinsic spin of the primary fragments in agreement with other published data. (auth) (UK)

15915 MASS DISTRIBUTION IN FISSION OF $^{237}Np$ WITH EPICADMIUM NEUTRONS. Stella, R.; Moretto, L. G.; Maxia, V.; Di Casa, M.; Crespi, V.; Rollier, M. A. (Univ., Pavia, Italy). J. Inorg. Nucl. Chem.; 31: 3739-45(Dec 1969).

The fission yields of seventeen mass chains in the mass region 93–153 were determined for the fission of $^{237}Np$ with epicadmium neutrons using radiochemical techniques. These yields have been determined by comparison with the corresponding yields in $^{235}U$ neutron induced fission using $^{140}Ba$ as internal standard. The mass yield distribution constructed with these data shows the two familiar broad peaks centered approximately at mass numbers 98 and 139. Such a distribution is compared with the corresponding distribution for $^{235}U$ and $^{239}Pu$ thermal neutron fission. (auth) (UK)

15916 QUADRUPOLE MOMENT OF THE 21.6-keV STATE OF $^{151}Eu$. Kalvius, G. M. (Argonne National Lab., Ill.); Shenoy, G. K.; Ehnholm, G. J.; Katila, T. E.; Lounasmaa, O. V.; Reivari, P. Phys. Rev.; 187: 1503-5(20 Nov 1969).

Moessbauer absorption in noncubic europium compounds ($EuSO_4$), $EuC_2O_4$, $EuCl_2$, $EuCO_3$) shows a combined magnetic and quadrupole interaction at very low temperatures. The nuclear quadrupole moment ratio for $^{151}Eu$, Q(21.6 keV)/Q(ground) = 1.30 ± 0.05, was obtained from measurements at 0.054°K. With Q(ground) = 1.16 b, Q(21.6 keV) = 1.51 b was determined. Earlier measurements are discussed in view of the present results. (auth)

15917 DELAYED γ RAYS FROM THERMAL-NEUTRON FISSION OF $^{235}U$ AND $^{239}Pu$. Berick, A. C.; Evans, A. E.; Meissner, J. A. (Los Alamos Scientific Lab., N. Mex.). Phys. Rev.; 187: 1506-12(20 Nov. 1969).

Measurements of the time dependence of delayed γ-ray activities from thermal-neutron fission of $^{235}U$ and $^{239}Pu$ were performed with a plastic scintillation detector for the time interval 0.01–4.0 sec after fission. Absolute intensities were obtained by normalizing these data to the results of Fisher and Engle which cover the time interval 0.2–45.0 sec after fission. The present results are in satisfactory agreement with Griffin's theoretical extrapolations to the msec region. (auth)

15918 ENERGY-DISTRIBUTION MEASUREMENT IN THE DOUBLE DECAY OF $^{130}Ba$. Ljubicic, A.; Hrastnik, B.; Ilakovac, K.; Knapp, V.; Vojnovic, B. (Inst. Rudjer Boskovic, Zagreb). Phys. Rev.; 187: 1512-16(20 Nov 1969).

The energy spectrum in the K-electron-photon double decay of

the 662-keV state of $^{137}$Ba was measured at an angle of 27°. The experimental data for photon energies above 70 keV are in good agreement with the theory of Spruch and Goertzel, in which the process is treated in an approximation as the internal Compton effect. At lower energies a disagreement was found. The contribution of the K-electron-photon double decay proceeding via nuclear intermediate states was estimated on the basis of previous results on double $\gamma$ decay, and was found to be negligible. (auth)

15919 ENERGY LEVELS OF $^{176}$Lu. Minor, M. M. (Florida State Univ., Tallahasse); Sheline, R. K.; Shera, E. B.; Jurney, E. T. Phys. Rev.; 187: 1516-28(20 Nov 1969).

The $\gamma$-ray spectrum from thermal-neutron capture in enriched targets of $^{175}$Lu was studied in four energy intervals using Ge(Li) and Si(Li) detectors. Twenty transitions in the energy region between 5.3 and 6.0 MeV were observed in $^{176}$Lu with a Ge(Li) detector operated in conjunction with a large NaI detector as a two-quantum escape spectrometer. Low-energy $\gamma$ radiation was measured from 20–1000 keV in both singles and $\gamma$–$\gamma$ coincidence experiments. Data from the reaction $^{176}$Lu(d,d′) were analyzed. The combination of results of these experiments with those previously reported in the literature resulted in the following spectroscopic interpretation of levels in $^{176}$Lu (denoted by band-head energy in keV, $K^{\pi}$, and Nilsson configuration): ground state, $7^-$[404 ↓ +514 ↓]; 126.5, I = 1, $0^-$[404 ↓ −514 ↓]; 198.0, $1^+$[404 ↓ −624 ↑]; 390.2, $1^-$[404 ↓ −512 ↑]; 662.0, $3^-$[404 ↓ −510 ↑]; and 791.5, $4^-$[404 ↓ +510 ↑]. The neutron separation energy of $^{176}$Lu is determined to be 6293 ± 4 keV. (auth)

15920 ISOMERISM IN $^{147}$Tb. Chu, Y. Y.; Franz, E. M.; Friedlander, G. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev.; 187: 1529-32(20 Nov 1969).

The previous assignment of a 24-min activity to $^{147}$Tb was found to be in error. Two $^{147}$Tb isomers with half-lives of 1.61 ± 0.17 h and 2.5 ± 0.1 min were found and their $\gamma$-ray spectra determined. The 1.6-h isomer appears to be the ground state, with spin-parity $\frac{5}{2}^-$; the 2.5-min $^{147m}$Tb is the high-spin state ($\geq$11/2). The half-life and prominent $\gamma$ rays of $^{147}$Gd were redetermined and two new $\gamma$ rays associated with the decay of 4.3-min $^{149m}$Tb are reported. (auth)

15921 TRANSITION MATRIX ELEMENTS IN THE EVEN–EVEN OSMIUM ISOTOPES: A COMPARISON WITH PAIRING-PLUS-QUADRUPOLE MODEL CALCULATIONS. Casten, R. F.; Greenberg, J. S.; Sie, S. H.; Burginyon, G. A.; Bromley, D. A. (Yale Univ., New Haven). Contract AT(30-1)-3223. Phys. Rev.; 187: 1532-54(20 Nov 1969).

The energy-level structures and transition matrix elements between collective excitations in the even-even osmium isotopes (A = 186 – 192) were studied using Coulomb excitation with oxygen projectiles having incident energies between 42 and 80 MeV. The deexcitation $\gamma$ radiations were observed with NaI(Tl) and Ge(Li) detectors, singly, in coincidence with inelastically backscattered $^{16}$O ions, and in coincidence with $\gamma$ rays from the $2^+ \rightarrow 0^+$ and $4^+ \rightarrow 2^+$ transitions in each isotope. Angular-correlation studies were performed on all observed transitions following Coulomb excitation by backscattered ions. In the four isotopes studied, all levels through the $6^+$ state of the ground-state band as well as the second excited $2^{+\prime}$ and $4^{+\prime}$ states were populated, and the transition moments associated with the excitation of these states were measured. In $^{192}$Os, previously unobserved radiations were assigned to the deexcitation of a $6^+$ state at 1088 keV and a $4^{+\prime}$ state at 907 keV. Except for the observation of the $0^+$ state at 1086 keV in $^{188}$Os, a search for low-lying $0^+$ states in the other osmium isotopes did not reveal any definite candidates. Electric-quadrupole transition matrix elements were deduced from the data with a model-independent analysis using the Winther-de Boer computer code for multiple Coulomb excitation. The latter quantities, together with measured branching ratios and B(M1) values, were compared with several macroscopic and microscopic nuclear models, with particular attention to the pairing-plus-quadrupole model of Kumar and Baranger. The latter has proved to be the most complete and successful of the models tested in predicting both absolute B(E2) values, and the variation of these with neutron number in the osmium isotopes. However, the model in its original form makes the transition from deformed to spherical shape more rapidly, with increasing mass, than appears to be the case experimentally, thereby suggesting the need for small variations in the relative strength of the pairing and quadrupole nucleon-nucleon residual forces assumed as input to the microscopic calculations. A description of the osmium isotopes, as typified by shallow potential minima for moderately prolate deformations (in the cases of $^{190,192}$Os asymmetric equilibrium configurations) and by pronounced softness to both $\beta$ and $\gamma$ vibrations, emerges from the comparisons made. (auth)

15922 VIBRATIONAL CHARACTER OF $^{104}$Pd AND A SPECTROSCOPIC STUDY OF $^{104}$Pd BY PICKUP REACTIONS. Dittmer, D. L.; Daehnick, W. W. (Univ. of Pittsburgh). Phys. Rev.; 187: 1553-65(20 Nov 1969).

The $^{105}$Pd(d,t)$^{104}$Pd and $^{107}$Ag(p,$\alpha$)$^{104}$Pd pickup reactions were studied at bombarding energies of 17 and 12 MeV, respectively. Tritons were detected by nuclear emulsions in an Enge split-pole spectrograph with 5–7-keV resolution, and 43 (d,t) angular distributions were measured for transitions to low-lying levels in $^{104}$Pd. Comparison of the (d,t) data with distorted-wave Born-approximation (DWBA) calculations predominantly led to l = 0, 2, and 4 assignments and yielded spectroscopic factors and quantitative estimates for single-neutron state occupancies. A previously postulated doublet at 1.33 MeV was resolved as a nearly degenerate triplet, in agreement with the two-phonon description for collective vibrations. Further evidence for the vibrational structure of the low-lying levels of $^{104}$Pd might be furnished by the well-isolated multiplet near 1.80 MeV, which may contain some or all of the members of the three-phonon quintet. In the (p,$\alpha$) experiment, cross sections were found to be very small (<20 $\mu$b/sr), and thick targets had to be used which limited the resolution to 40 keV for Si detector data and $\lesssim$30 keV for magnetic spectrograph analysis. (p,$\alpha$) angular distributions are given for the four strongest groups below 2 MeV. Very good agreement between the experimental results and j-dependent DWBA calculations based on a triton-cluster transfer mechanism supports the interpretation that direct pickup is the dominant (p,$\alpha$) reaction process in this mass and energy region. (auth)

15923 PRECISE MEASUREMENT OF THE MUONIC X RAYS IN THE LEAD ISOTOPES. Anderson, H. L. (Univ. of Chicago); Hargrove, C. K.; Hincks, E. P.; McAndrew, J. D.; McKee, R. J.; Barton, R. D.; Kessler, D. Phys. Rev.; 187: 1565-96(20 Nov 1969).

The size and shape of the nuclear charge distribution was determined for the Pb isotopes from precise measurements of their $\mu$-atomic transition energies. Use of the 2p-1s transitions was avoided in determining the nuclear parameters because of the perturbation caused by the presence of the muon in the 1s orbit. A simple two-parameter Fermi distribution was used in the analysis, but the rms radius determined thereby should be fairly model-independent. A value of $\langle r^2 \rangle^{\frac{1}{2}} = 5.4839 \pm 0.0028$ fm for $^{206}$Pb was found. This quantity increases by 0.0139 ± 0.0011 fm in going to $^{208}$Pb. The calculated energy of the 1s level is found to be too high by 6.8 ± 2.3 keV, an effect which is interpreted as being due to nuclear polarization, although the inadequacies in the treatment of the radiative corrections and of the effect of nuclear motion may account for a part of this difference. The measurement of the 4f-3d and 5g-4f transition energies provides a check of the vacuum-polarization correction, which is just at the limit of the higher-order contributions. The intensity ratios $I(2p_{\frac{3}{2}}\text{-}1s_{\frac{1}{2}})/I(2p_{\frac{1}{2}}\text{-}1s_{\frac{1}{2}})$ are found to be anomalously low for all three Pb isotopes and by as much as (12 ± 3)% in the case of $^{208}$Pb. In general, the intensities are reasonably well described by a cascade calculation, but the indication is that radiationless transitions do occur which can raise the Pb nucleus to an excited state. Prompt nuclear $\gamma$ rays corresponding to this process were detected. Some 15 $\mu$-capture $\gamma$ rays with yields $\geq$0.01 per $\mu$ capture are reported for $^{208}$Pb. One with a yield of 0.18 per $\mu$ capture is attributed to the $\frac{3}{2}^+ \rightarrow \frac{1}{2}^+$ g.s. transition in $^{205}$Tl, following the emission of one neutron. (auth)

15924 FRAGMENT ENERGY AND VELOCITY MEASUREMENTS IN FISSION OF URANIUM BY 2.9-GeV PROTONS. Remsberg, L. P.; Plasil, F.; Cumming, J. B.; Perlman, M. L. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev.; 187: 1597-1609 (20 Nov 1969).

Fission of uranium induced by 2.9-GeV protons was studied with semiconductor detectors and velocity-measuring devices. The angular correlation between members of fission-fragment pairs as well as the energies of the two fragments and the velocities of one was determined. Fragment masses were thus ascertained. From these data, deductions were made about excitation energies and momenta of the fissioning systems. The results show that although there is a much broader mass spectrum of fissioning nuclei produced at 2.9 GeV than is present at lower bombarding energies, the fission mechanisms in the two cases are indistinguishable. Mean fragment velocities are found to be very nearly independent of fissioning-system mass, in agreement with calculations based on a liquid-drop model. (auth)

15925 ELASTIC AND INELASTIC PROTON SCATTERING FROM $^{110}$Pd. Robinson, R. L.; Ford, J. L. C. Jr.; Stelson, P. H.; Tamura, T.; Wong, C. Y. (Oak Ridge National Lab., Tenn.). Phys. Rev.; 187: 1609-17(20 Nov 1969).

The differential cross sections for elastically and inelastically scattered 13.0-MeV protons from $^{110}$Pd were measured for 26 groups to levels below ~3 MeV. Optical-model parameters were obtained from a fit of the elastic data. A comparison of the predictions given by the distorted-wave theory with the experimental results for the strongly excited $2^+$ level at 0.374 MeV and $3^-$ level at 2.038 MeV yielded values of 0.241 for $\beta_2$ and 0.134 for $\beta_3$, where $\beta_\lambda$ is the deformation parameter of multipolarity $\lambda$. The coupled-channel theory was used to calculate cross sections for the two-quadrupole, the one-octupole–one-quadrupole, and the $6^+$ three-quadrupole phonon states. It was only possible to explain the strong diffraction pattern for the cross section of the second $2^+$ state by admixing the one- and two-quadrupole phonon states. Coupled-channel predictions suggest tentative spin parities of $1^-$, $3^-$ or $5^-$, $3^-$, and $3^-$ for states at 2.135, 2.193, 2.446, and 2.778 MeV, respectively. For the $6^+$ three-quadrupole phonon state, the calculated cross sections are similar to those for proton groups exciting the 1.713- and 1.933-MeV states. (auth)

15926 ENERGY LEVELS OF $^{100}$Ru. Berzins, G.; Bunker, M. E.; Starner, J. W. (Los Alamos Scientific Lab., N. Mex.). Phys. Rev.; 187: 1618-32(20 Nov 1969).

The nuclear-level structure of $^{100}$Ru was investigated through study of the radioactive decay of 16-sec $^{100}$Tc and 20-h $^{100}$Rh. The experimental techniques employed include two-parameter Ge(Li)-Ge(Li) coincidence spectroscopy and NaI(Tl) $\gamma$–$\gamma$ angular-correlation measurements. Altogether, 24 excited states of $^{100}$Ru were observed below 3.5 MeV. Examination of previous Ru(n,$\gamma$) data strongly suggests that at least seven of the observed levels are populated by primary $^{99}$Ru(n,$\gamma$) transitions. The present results, combined with previous internal-conversion and angular-correlation data, yield unique spin-parity assignments for nine levels, four of which are $0^+$ (at 1130.4, 1740.6, 2051.5, and 2387 keV). Also, through selection-rule arguments, narrow limits were placed on the spin-parity values for the remaining states, almost all of which are of low spin ($\leq$2). The assignments deduced for the parent nuclei are $1^+$ for $^{100}$Tc and $1^-$ for $^{100}$Rh. The $\beta$ branching of $^{100}$Tc is found to be anomalous in that the transitions to the lowest two $2^+$ levels are extremely hindered compared to those that proceed to the lowest two $0^+$ levels. (auth)

15927 LEVEL SCHEME OF $^{153}$Sm BASED ON (n,$\gamma$), (n,e$^-$), AND $\beta$-DECAY EXPERIMENTS. Smither, R. K (Argonne National Lab., Ill); Bieber, E.; von Egidy, T.; Kaiser, W.; Wien, K. Phys. Rev.; 187: 1632-71(20 Nov 1969).

The $^{152}$Sm(n,$\gamma$)$^{153}$Sm spectrum was measured with a bent-crystal spectrometer and with a Ge(Li) detector. The low-energy bent-crystal spectrum consisted of 251 $\gamma$ transitions associated with thermal-neutron capture in $^{152}$Sm, with energies between 28 and 1041 keV. The $\gamma$-ray intensities were normalized to the previously established intensity of the 103-keV line in $^{153}$Eu from the $\beta$ decay of $^{153}$Sm. The energies and intensities of 24 other lines associated with this $\beta$ decay are also given. The high-energy (n,$\gamma$) spectrum, containing 23 lines between 4.5 and 5.9 MeV, was obtained with a Ge(Li) detector. The neutron binding energy of $^{153}$Sm was found to be 5869.3 ± 2.0 keV. The conversion-electron spectrum, measured with a high-resolution magnetic spectrometer, was used to obtain K and L conversion coefficients and corresponding multipole assignments for 37 of the low-energy $\gamma$ transitions. The $\gamma$ spectrum in $^{153}$Sm following $\beta$ decay of $^{153}$Pm was measured with Ge(Li) and Si(Li) detectors. The (n,$\gamma$), (n,e$^-$), and $\beta$-decay experiments were combined to develop the level scheme of $^{153}$Sm, in which unique spin and parity assignments are made for 13 of the 28 levels below 750 keV. The energy (keV) and $J^\pi$ of the first 28 levels are: 0.000, $3/2^+$; 7.535, $5/2^+$; 35.843, $3/2^-$; 53.533, $1/2^+$ or $(5/2^+)$; 65.475, $5/2^+$ or $1/2^+$ or $3/2^+$; 90.874, $5/2^-$; 112.954, $3/2^+$ or $1/2^\pm$ or $5/2^\pm$; 127.298, $7/2^-$; 174.17, $7/2^-$; 182.90, $5/2^-$; (194.65), $1/2^\pm$ or $7/2^+$; 262.33, $1/2^+$ or $(5/2^+)$; (265.93), $7/2^-$ or $(5/2^\pm)$; 276.71, $3/2^+$; 321.11, $3/2^+$; 356.69, $5/2^+$; 362.29, $5/2^+$; (371.04), $3/2$ or $7/2$; 405.46, $3/2^-$; 414.91, $1/2^+$ or $3/2^+$; 447.07, $3/2$ or $7/2$; 450.04, $1/2$ or $7/2$; 481.08, $3/2^+$; 524.36, $5/2$; 630.20, $7/2^{(-)}$; 695.83, $1/2^{(+)}$; or $3/2^{(+)}$; 734.90, $5/2$; and 750.32, $1/2$ or $5/2$. Of special interest is the very low-energy (7.53 keV) first excited state with $J^\pi = 1/2^+$, which appears to be the second member of the strongly distorted ground-state rotational band. A good match between the theoretical predictions of the Nilsson model and the observed $\gamma$-ray branching ratio was obtained when nine of the eleven levels below 200 keV were assigned to a positive-parity, $K = 3/2$, ground-state rotational band and two negative-parity, $K = 3/2$, rotational bands with band heads at 35.84 and 127.30 keV. (auth)

15928 FISSILE NUCLEI OF MEDIUM MASS WITH NANO-SECOND LIFETIMES. Ruddy, Frank H.; Alexander, John M. (State Univ. of New York, Stony Brook). Phys. Rev.; 187: 1672-9(20 Nov 1969).

Targets of $^{138}$Ba to $^{209}$Bi were bombarded with various heavy ions, $^{11}$B to $^{19}$F. In a number of cases fission was observed to occur from nuclei that must have mean lives of several nanoseconds and cross sections of the order of 10 $\mu$b. There are strong indications that the major reactions responsible for producing these products are of the compound-nucleus type. This type of fission appears to be rather common for $Z \approx 66$ and $Z \approx 84$. (auth)

15929 ELECTRIC DIPOLE TRANSITIONS FROM THE 2.6-MeV SEPTUPLET IN $^{209}$Bi. Metzger, F. R. (Franklin Inst., Swarthmore, Pa.). Phys. Rev.; 187: 1680-2(20 Nov 1969).

The resonant scattering of electron bremsstrahlung by the $1/2^+$, $3/2^+$, and $11/2^+$ members of the 2.6-MeV septuplet in $^{209}$Bi was studied. On the basis of the scattered intensities, and assuming ground-state branching ratios $\Gamma_0/\Gamma$ of 0.5, 1.0, and 1.0, respectively, ground-state transition widths of $\Gamma_0(2.581, 1/2^+) < 10$ meV, $\Gamma_0(2.563, 3/2^+) = 30 \pm 5$ meV, and $\Gamma_0(2.598, 11/2^+) = 9.0 \pm 2.4$ meV were obtained. The observed transition strengths agree well with the predictions of the particle-vibration model in the form used by Hamamoto, with $e_{eff}(E1) = 0.05$. (auth)

15930 NUCLEAR-STRUCTURE STUDIES OF $^{91,92,93,95,97}$Nb AND $^{94}$Mo WITH THE ($^3$He,d) REACTION. Cates, M. R.; Ball, J. B.; Newman, E. (Oak Ridge National Lab., Tenn.). Phys. Rev.; 187: 1682-99(20 Nov 1969).

The structure of the low-lying levels of $^{91,92,93,95,97}$Nb and $^{94}$Mo was investigated with the proton-stripping ($^3$He,d) reaction on targets of $^{90,91,92,94,96}$Zr and $^{93}$Nb. The incident energy was 30.9 MeV for the $^{91,92}$Zr and $^{93}$Nb reactions and 24.7 MeV for the $^{94,96}$Zr reactions. The $^{90}$Zr reaction was studied at both energies. The experimental angular distributions are compared with local zero-range distorted-wave Born-approximation calculations, and spin, parity, and spectroscopic factors are deduced. The extracted spectroscopic factors are used to establish the proton configurations of the target ground states. The observed levels and spectroscopic factors are compared with shell-model predictions based on an $^{88}$Sr core. A surprising deviation from results of the simple shell-model calculations is observed for the relative transfer strengths to the two lowest 2+ levels in $^{94}$Mo. (auth)

15931 WIDTH OF THE 2.186-MeV $1^-$ LEVEL IN $^{144}$Nd. Metzger, F. R. (Franklin Inst., Swarthmore, Pa.). Phys. Rev.; 187: 1700-4(20 Nov 1969).

The resonant scattering of $\gamma$ rays was observed for the 2.186-MeV $1^-$ state in $^{144}$Nd. The electron bremsstrahlung from a Van de Graaff accelerator served as the exciting $\gamma$ radiation. The scattered radiation was observed with a 40-cm$^3$ Ge(Li) detector. If the value $\Gamma_0/\Gamma = 0.71$ is used for the branching ratio, the measured scattering yield corresponds to a partial width $\Gamma_0 = (3.1 \pm 0.4) \times 10^{-2}$ eV for the ground-state transition. The reduced E1 transition probability for the ground-state transition is intermediate between the B(E1)'s for the "spherical" nucleus $^{148}$Sm and the deformed nucleus $^{152}$Sm. A level with spin 2 and with an excitation energy of 2.074 MeV was also excited in $^{144}$Nd. From the observed scattering, $\Gamma_0^2/\Gamma = (1.2 \pm 0.3) \times 10^{-3}$ eV is obtained for this level. (auth)

15932 E3 ISOMER IN $^{105}$Ag. Hopke, P. K.; Naumann, R. A.; Spejewski, E. H.; Strigachev, A. T. (Princeton Univ., N. J.). Phys. Rev.; 187: 1704-8(20 Nov 1969).

An E3 isomer was found in $^{105}$Ag. The isomeric transition with half-life 7.23 ± 0.16 min is attributed to a 25-5-keV transition to the ground state. Electron-capture branching to known levels in $^{105}$Pd was observed. The reduced radiative lifetimes of the five E3 isomers now known in odd-A silver isotopes are compared and found to be constant within a factor of 2. (auth)

15933 LEVELS IN $^{203}$Bi, $^{205}$Bi, AND $^{207}$Bi. Hopke, P. K.; Naumann, R. A.; Spejewski, E. H. (Princeton Univ., N. J.). Phys. Rev.; 187: 1709-21(20 Nov 1969).

The decay of the odd-mass isotopes of polonium to levels in $^{203}$Bi, $^{205}$Bi, and $^{207}$Bi was studied. Isotopically separated sources were produced in an accelerator and mass-dispersed by means of an electromagnetic isotope separator. Gamma-ray and conversion-electron spectra were observed. With the aid of $\gamma$–$\gamma$ coincidences, level schemes were constructed for these three bismuth isotopes. (auth)

15934 LEVELS OF $^{124}$Te FROM THE DECAY OF 4.2-DAY $^{124}$I. Ragaini, R. C. (Massachusetts Inst. of Tech., Cambridge); Walters, W. B.; Meyer, R. A. Contract AT(30-1)-905. Phys. Rev.; 187: 1721-32(20 Nov 1969).

The population of levels of $^{124}$Te from the decay of 4.2-day $^{124}$I was investigated by studying the $^{124}$I $\gamma$ rays with a Ge(Li) Compton suppression spectrometer and with NaI(Tl)-Ge(Li) coincidence systems. Seventy-two $\gamma$ rays were identified as originating from $^{124}$I, and 62 of them were assigned to 24 levels of $^{124}$Te. The levels populated from $^{124}$I decay are compared to the levels of $^{124}$Te populated from the decay of the $^{124}$Sb isomers. The nature of the levels

is discussed in the framework of the quasiparticle and spherical vibrational models. (auth)

15935 PROJECTED BCS–TAMM–DANCOFF APPROXIMATION FOR EVEN TIN ISOTOPES. Ottaviani, P. L. (Univ., Trieste, Italy); Savoia, M. Phys. Rev.; 187: 1306-14(20 Nov 1969).

A model for even "superconductor" nuclei is proposed and developed. In this model the ground state is approximated by the component of a Bardeen–Cooper–Schrieffer (BCS) state corresponding to a fixed particle number. The low-lying excited states are then obtained by diagonalizing the nuclear Hamiltonian in the space spanned by the particle-hole elementary excitations and, for J = 0, by the ground state itself. Expressions for the matrix elements of the electromagnetic operators are also given. The results obtained from this model for some even tin isotopes are compared with the experimental results and the corresponding results of an ordinary BCS–Tamm–Dancoff approximation. Thus, a direct evaluation of the effects of the particle-number nonconservation in the Tamm–Dancoff approximation is given. (auth)

15936 DECAY STUDY OF $^{117}$I AND $^{119}$I. Ladenbauer-Bellis, I. M.; Bakhru, H.; Luzzati, A. (Yale Univ., New Haven). Phys. Rev.; 187: 1739-44(20 Nov 1969).

The decay of $^{117}$I was studied with two Ge(Li) detectors and several NaI(Tl) crystals. The isotope was produced by $^{12}$C ion bombardment (6.8 MeV/N) on natural Ag targets. The following $\gamma$ rays were found: 274 ± 1, 325 ± 1, and 599 ± 1 keV. A half-life of 2.7 ± 0.2 min was observed. $^{119}$I was formed via the reaction of natural Ag with 57-MeV $^{12}$C ions. A $\gamma$ line of 255 ± 1 keV with a half-life of 18.0 ± 0.5 min was recorded. (auth)

15937 SUPER ELEMENTS. Lombard, Roland (CNRS, Orsay, France). Ind. At.; 13: No. 11-12, 27-36(1969). (In French).

The study of very heavy elements with numbers of charges between 110 and 126 is currently arousing a great deal of interest. The various theoretical arguments on which speculations are based are reviewed. The existence of these super-elements seems, among other matters, to be closely linked to the layer structure. The possibilities of demonstrating this are briefly discussed. (auth)

15938 INVESTIGATION OF THE BOHR-INDEPENDENCE HYPOTHESIS FOR NUCLEAR REACTIONS IN THE CONTINUUM: $\alpha$ + $^{59}$Co, p + $^{62}$Ni AND $\alpha$ + $^{56}$Fe, p + $^{59}$Co. Fluss, M. J.; Miller, J. M.; D'Auria, J. M.; Dudey, N.; Foreman, B. M. Jr.; Kowalski, L.; Reedy, R. C. (Columbia Univ., New York). Phys. Rev.; 187: 1449-65(20 Nov 1969).

Measurements were made of the energy spectra at various angles of protons and $\alpha$ particles emitted from the reactions of protons with $^{62}$Ni and $\alpha$ particles with $^{59}$Co to determine the extent to which the deexcitation of the reaction intermediate, $^{63}$Cu at 20.2-MeV excitation energy, is independent of its mode of formation. Similarly, the reaction intermediate $^{60}$Ni at 23.6 MeV was formed by protons on $^{59}$Co and $\alpha$ particles on $^{56}$Fe, again to determine to what degree its deexcitation by proton and $\alpha$-particle emission is independent of its mode of formation. Small differences in the shapes of corresponding energy spectra [(p,p') versus ($\alpha$,p), and ($\alpha$,$\alpha$') versus (p,$\alpha$)] that were observed in apparent violation of the Bohr-independence hypothesis are removed after account has been taken of the effects of angular-momentum conservation. The observed enhancement of the ratio of cross sections $\sigma$(x,p)/$\sigma$(x,$\alpha$) for the proton entrance channel over that for the $\alpha$ entrance channel cannot be interpreted in terms of angular-momentum conservation. The consequences of the possibility of isotopic-spin conservation, when considered, lead to enhanced proton reemission similar to that observed experimentally. (auth)

15939 A STUDY OF ENERGY LEVELS IN ODD-MASS ERBIUM NUCLEI BY MEANS OF (d,p) AND (d,t) REACTIONS. Tjoem, P. O.; Elbek, B. Kgl. Dan. Vidensk. Selsk., Mat.-Fys. Medd.; 37: No. 7, 1-44(1969).

The energy levels of $^{161}$Er, $^{163}$Er, $^{165}$Er, $^{167}$Er, $^{169}$Er and $^{171}$Er were investigated by means of (d,p) and (d,t) reactions on the stable erbium isotopes. The deuteron energy was 12.1 MeV and the charged reaction products were analyzed in a magnetic spectrograph of 60, 90, and 125°. A total of 16 different Nilsson orbitals or components therefore were identified on the basis of the intensity patterns for the rotational states, the absolute cross sections, and the rate of intensity change with angle. For the majority of the orbitals, the observations are in reasonable agreement with the theoretical predictions based on the single-particle functions in a deformed potential. A few of the observed intensities do, however, deviate considerably from the theoretical intensities. Among the reasons for such deviations are the crossing of energy levels from different oscillator shells and couplings to other single-particle states or collective vibrations, but for a number of cases no obvious explanation has yet been found. (auth)

15940 ABSOLUTE MEASUREMENT OF THE ANGULAR CORRELATION OF INTERNAL BREMSSTRAHLUNG FROM $^{90}$Y. Kreische, W.; Lampert, W.; Loos, G.; Weltie, D. (Univ., Erlangen, Ger.). Phys. Lett.; 30B: 514-15(22 Dec 1969). (In German).

The integral angular correlation of the internal bremsstrahlung of the $\beta$-decay of $^{90}$Y was measured. The experiments are in better agreement with calculations of Ford and Martin, who take into account detour transitions, than with a modified KUB-theory. (auth)

15941 ISOSPIN-FORBIDDEN ANALOG RESONANCE IN DIRECT REACTIONS. Tamura, T.; Coker, R. (Univ. of Texas, Austin). Phys. Lett.; 30B: 581-4(22 Dec 1969).

A theoretical description of isospin-forbidden analog resonances in direct reactions, using the K-matrix approach to analog resonances, is applied in numerical calculations for $^{207}$Pb(d,p) $^{208}$Pb(0$^+$, ground state). Satisfactory agreement with the experimental data of Hamburger is obtained. (auth)

15942 THE /NON-/ EXISTENCE OF A LONG-LIVED $^{141}$Sm. Sverdrup, T.; Alstad, J. (Univ. of Oslo, Blindern, Norway). Radiochem. Radioanal. Lett.; 2: 239-48(27 Dec 1969).

A careful investigation of a possible long-lived $^{141}$Sm was performed. When samarium isotopes are produced by high-energy proton bombardments of uranium a long-lived component appears whose half-life is comparable with an old published value (17.5–22 days). The present work shows that the component consists of radiochemical impurities of europium and gadolinium. (auth)

15943 NUCLEAR RESONANT SCATTERING OF ANNIHILATION QUANTA. Davydov, A. V. (Inst. for Theoretical and Experimental Physics, Moscow); Kartashov, G. R.; Vishnevskii, I. N. Phys. Lett.; 30B: 816-17(22 Dec 1969).

Resonant scattering by $^{106}$Pd nuclei of $\gamma$-quanta produced by positron annihilation in metallic copper was observed. The differential cross section of this process for a scattering angle of 120° was found to be 0.27 ± 0.05 mb/sr. (auth)

15944 A STUDY OF COUPLING CONDITIONS IN SUB-THRESHOLD FISSION OF $^{237}$Np BY MEANS OF GAMMA-RAY SPECTRA. Weigmann, H.; Rohr, G.; Winter, J. (EURATOM, Geel, Belg.). Phys. Lett.; 30B: 624-5(22 Dec 1969).

Neutron radiative capture at $^{237}$Np resonances was studied with Ge(Li) and NaI detectors. From the observed spectra it is concluded that the intermediate structure in sub-threshold fission of $^{237}$Np is due to broad intermediate states with very small spreading width. (auth)

15945 ANOMALOUS BEHAVIOR OF l = 0 TRANSITIONS IN $^{98}$Mo(d,p) AND $^{100}$Mo(d,t) REACTIONS. Diehl, R. C.; Cohen, B. L.; Moyer, R. A. (Univ. of Pittsburgh). Phys. Lett.; 30B: 637-8(22 Dec 1969).

The states of $^{99}$Mo dominantly populated by l = 0 transitions in $^{98}$Mo(d,p) and in $^{100}$Mo(d,t) are not the same. The ratio S(d,t)/S(d,p) for these states differs by a factor of 21 which is an order of magnitude larger than in any other known case. This represents a breakdown of the quasi-particle model. (auth)

## Nuclear Theory

*Refer also to abstracts 14290, 14356, 15226, 15601, 15606, 15616, 15688, 15780, 15789, 15859, and 15941.*

15946 (AAEC/TM–515) THE STATISTICAL ESTIMATION OF THE AVERAGE RESONANCE SPACING IN EVEN-A AND ODD-A NUCLEI. Musgrove, A. R. de L. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Sep 1969. 25p. Dep. CFSTI (U. S. Sales Only).

The statistical "best estimate" for the average level spacing ⟨D⟩ is calculated for even-A and odd-A target nuclei which form respectively one and two spin sequences when bombarded with s-wave neutrons. The expected error in the estimate is also given and is dependent on the spin of the target nucleus. (auth)

15947 (LYCEN–6955) SEPARABLE POTENTIALS IN $\alpha$–$\alpha$ ELASTIC SCATTERING BELOW 30 MeV. Pigeon, J.; Barguil, J.; Fayard, C.; Lamot, C.; El Baz, E. (Lyon Univ. (France). Institut de Physique Nucleaire). 8 Dec 1969. 24 p. Dep. CFSTI (U. S. Sales Only).

The use of non-local separable potentials leads to a simple analytical expression for the elastic scattering processes, even when the Coulomb effect is taken into account. The nuclear phase

shift is given by an explicit formula identical to that in the neutral particle case, except that the separable potential is expressed by a $\{\chi_k^-\}$ representation. The formalism described has been used in $\alpha-\alpha$ elastic scattering below 30 MeV. The parameters concerned have been determined by comparison with experimental data, and close agreement with the experimental nuclear phase shift has been obtained. (France)

15948 (ORNL-TM-2816) VARIATION OF THE R-MATRIX. Mockel, A. J.; Perez, R. B. (Oak Ridge National Lab., Tenn.). 9 Jan 1970. 40p. Dep. CFSTI.

The R-matrix of Wigner and Eisenbud is a functional of a set of parameters (channel radii, boundary numbers, etc.) as well as of the energy of the incoming particle. Invariant embedding techniques were applied, which give the variation of the R-matrix with respect to changes of the parameters entering in the theory. A generalization of various formulas, derived originally by Wigner and Teichmann and Wigner, to the multichannel case was obtained. The general results apply also to deformations of the nucleus other than spherical. An application of the invariant embedding technique is also shown concerning Robson's theory of the isobaric spin analogues. (auth)

15949 (UJV-2261-F) A COMMENT TO THE BHMM ANALYSIS OF THE DEUTERON STRIPPING. Dobes, J. (Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu). Aug 1969. 6p. Dep. CFSTI (U. S. Sales Only).

The BHMM theory of deuteron stripping reactions is analyzed and subjected to criticism. Its use in analyses of reactions with spectroscopic factors close to unity is questioned. (auth)

15950 THE THEORY OF BETA-DECAY. Strachan, C. Oxford; Pergamon Press (1969). 221p. 30s.

The subject is discussed under the following headings: Part I. Quantum theoretical background; the interaction Hamiltonian-beta-ray spectra and decay probabilities; further developments (non-conservation of parity; helicity and the two-component theory of the neutrino; possible invariance under time-reversal and charge conjugation; "leptonic number" or "leptonic charge"; muon decay and the conserved vector current theory; "weak magnetism"; current-current formulation-universal weak interaction-Cabibbo theory). Part II. Tentative theory of $\beta$-radiation; detection of the free neutrino; selection rules for $\beta$-disintegration; question of purity conservation in weak interactions; experimental test of parity conservation in $\beta$-decay; parity non-conservation and two-component theory of the neutrino; helicity of neutrinos; theory of the Fermi interaction; test of nature of vector interaction in $\beta$-decay. (UK)

15951 NUCLEAR SPECTRA CALCULATIONS USING REALISTIC INTERACTIONS AND REALISTIC SINGLE-PARTICLE WAVEFUNCTIONS. Scott, Colin Keith. Montreal; McGill Univ. (1969).

Thesis.

Nuclear spectra of A = 14, 18, 38, 42, 206 and 208 nuclei were calculated using free reaction matrices as effective interactions and Woods-Saxon single-particle wavefunctions. The calculations show that, in most of the cases considered, realistic single-particle wavefunctions must be used in the determination of realistic effective interaction matrix elements. The results are especially interesting in the A = 18 nuclei where it is found that the use of realistic single-particle wavefunctions produce changes in spectra comparable to those introduced by core-polarization. In heavier nuclei it appears that a simple harmonic oscillator calculation is out of the question at least for states involving both neutrons and protons. Wavefunctions deduced for a single value of the oscillator parameter $\hbar\omega$ cannot adequately describe the states in nuclei such as $^{208}$Pb and $^{216}$Pb possessing a large neutron excess. (Diss. Abstr.)

15952 INTERMEDIATE STRUCTURE, FINE STRUCTURE, AND ISOBARIC ANALOG RESONANCES. Mekjian, Aram. College Park, Md.; Univ. of Maryland (1968). 146p.

Thesis.

A shell model description of the origin and structure of analog states is presented. An analog spin formalism is used since proton and neutron central potentials are chosen to be different. The coupling mechanisms that exist between the W > analog state and the W < hallway states and W < configurational states are discussed. In particular, the direct Coulomb coupling and the external mixing of Robson are considered. These two types of couplings are treated on an equal footing. The intermediate structure and fine structure associated with analog state resonances are discussed in terms of doorways and hallways. The consequences of an isobaric or analog spin formalism on the particle-hole structure of the hallways are considered. A K-matrix formulation of a shell model theory of nuclear reactions is used to describe the distribution of resonance width of this fine structure. General conditions for a full suppression of the fine structure are established for the one and many open channel case. Expressions for various parameters describing the distribution of widths are developed which include the effects of internal and external mixing. Values for internal and external mixing couplings are obtained for a series of nuclei. The suppression point shift and spreading width arising from internal and external mixing are calculated. The question of whether a charge dependent nuclear interaction can account for a significant fraction of the spreading width is considered. The isobaric spin impurity of analog state resonances is calculated for both types of mixing. The question of internal mixing and the observability of an asymmetric distribution of fine structure widths is discussed. (Diss. Abstr.)

15953 FREE AND EFFECTIVE N-N INTERACTIONS AND THE STRUCTURE OF LIGHT NUCLEI. Ramirez, Susana; Yepez, E. de Llano, M. (Univ. Nacional de Mexico, Mexico City). Rev. Mex. Fis.; 18: 283-304(1969).

The differences between "free" and "effectivized" nucleon-nucleon interactions are studied through their effects on the binding energies of $^3$H, $^4$He, $^{16}$O, as well as the energy spectrum of $^6$Li, by assuming the simplest oscillator shell model configuration for each: $(Os)^3$, $(Os)^4$, $(Os)^4(Op)^{12}$ and $(Os)^4(Op)^2$, respectively. Soft-cored, realistic N-N potentials are used, as well as effective interaction matrix elements of various kinds. The need to "renormalize" a free N-N interaction whenever one does a restricted configuration space secular problem is clearly manifested. (auth)

15954 MODEL-INDEPENDENT CALCULATION OF THE ALPHA AND BETA STABILITY OF SUPERHEAVY NUCLEI. Lightman, A. P.; Gerace, W. J. (Princeton Univ., N. J.). Phys. Lett.; 30B: 526-8(8 Dec 1969).

The point functions of the Garvey-Kelson nuclidic mass relation are projected, enabling the construction of an entire mass table in the superheavy region. The stability of these nuclei against alpha and beta decay is calculated and it is found that, although Z = 114 may well be a magic proton number, other isotones of N = 184 have longer alpha half-lives. Furthermore all isotopes of Z = 126 are found to be both alpha and beta unstable. (auth)

15955 PSEUDO LS COUPLING AND PSEUDO $SU_3$ COUPLING SCHEMES. Arima, A. (State Univ. of New York, Stony Brook); Harvey, M.; Shimizu, K. Contract AT(30-1)-4032. Phys. Lett.; 30B: 517-22(8 Dec 1969).

The advantages of pseudo coupling schemes in nuclear structure calculations using surface interactions are discussed. Some results for Ni isotopes, in which pseudo LS and pseudo $SU_3$ coupling schemes were used, are presented. (J.W.R.)

15956 POSSIBLE SCHEME FOR ANALYZING DIRECT NUCLEAR REACTIONS. Shanley, Paul E. (Univ. of Notre Dame, Ind.). Phys. Rev. Lett.; 24: 18-21(5 Jan 1970).

A technique of data analysis familiar in nucleon-nucleon scattering is proposed for use in the extraction of spectroscopic information from direct nuclear reactions. The method is shown to be successful in analyzing some artificial data generated by a soluble three-body model of deuteron stripping. (auth)

15957 EFFECTS OF FINITE RANGE AND EXCHANGE INTERACTIONS IN (p,n) AND (n,p) KNOCKOUT REACTIONS. Liu, Kuang-hsiang. Austin, Tex.; Univ. of Texas (1968). 112p.

Thesis.

Angular distributions based on the distorted wave Born approximation taking into account the effects of finite range and exchange interaction were calculated for four (p,n) and one (n,p) knockout reactions for target nuclei with atomic mass numbers between 13 and 91, for bombarding energies from 5.3 to 20 MeV, and for a wide range of bound state orbital angular momenta. Finite range is treated both exactly and approximately, using various approximations, and the results are compared with each other. An admixture of Wigner, Majorana, Bartlett, and Heisenberg interactions with a Yukawa potential form factor is assumed for the neutron-proton interaction. The Saxon-Wood potential is used to evaluate the bound state wave functions. Experimental comparisons were made for the $^{13}$C(p,n)$^{13}$N and the $^{28}$Si(n,p)$^{28}$Al ground state reactions. Neither the zero range approximation, nor any of the other approximations considered yield results which are quantitatively consistently reliable. For exact comparison there appears to be no substitute for the exact calculation at the present time. Many of the cross sections exhibit a great sensitivity to exchange mixtures at certain angles, as well as to the bound state wave functions, and it may be possible in future investigations to take ad-

vantage of this property to determine various nuclear parameters. (Diss. Abstr. Int., B)

15958 EFFECTIVE NUCLEON–NUCLEON INTERACTIONS AND THE MICROSCOPIC DESCRIPTION OF NUCLEON–NUCLEUS SCATTERING. Love, William Gary. Knoxville, Tenn.; Univ. of Tennessee (1968). 145p.

Thesis.

A microscopic description of the inelastic scattering of nucleons from nuclei is attempted. Of particular interest in this work are those low-lying levels in nuclei near closed shells. More specifically, an effective nucleon-nucleon interaction, $t_{eff}$, is sought which, when used in the distorted wave approximation, yields the correct transition amplitudes between two nuclear states of the above type. Since at very high energies the impulse approximation should be valid, it is used as a guide at the energies with which this work is concerned (e.g., $E \lesssim 150$ MeV). For all energies in this range the impulse approximation is found to be too weak when a simple shell model description of the nuclear states is used. For example, near 20 MeV it is found to predict less than 10 percent of the observed cross section. To investigate $t_{eff}$ and consequently its departure from the impulse approximation, attention is focused on two principal aspects of the problem: (1) the inclusion of core polarization effects, and (2) the inclusion of exchange or knock-out terms in the transition amplitudes. The inclusion of the effects due to core polarization involves a renormalization of the effective interaction between the projectile and the valence nucleons of the target induced by closed shell or "core" participation in intermediate excited states. This renormalization has been carried out in perturbation theory where a macroscopic model of the core is used. The core coupling parameters are obtained by applying this model to the relevant electromagnetic transitions for which the interaction is known. This model has been applied to the scattering of nucleons with bombarding energies from 10 to 150 MeV from several nuclei near closed shells with the result that core polarization effects are found to be extremely important. In fact, in this energy range these effects are found to dominate the impulse approximation. However, the impulse approximation plus the core coupling term is still too weak below about 60 MeV. Presently the inclusion of exchange effects of the knock-out type are being considered also. Although there are no results of numerical calculations to report as yet, the formalism is developed and a qualitative study of these knock-out terms is presented. The necessary computer program is currently being developed. This phase of the study should allow one to critically evaluate terms that have been until recently almost universally ignored. These knock-out terms introduce amplitudes that are forbidden by the direct theory alone and should be interesting to study as mechanisms for "direct forbidden" transitions. (Diss. Abstr. Int., B)

15959 MODEL-INDEPENDENT ANALYSIS OF INELASTIC ELECTRON SCATTERING FROM NUCLEI. II. MONOPOLE EXCITATIONS AT ARBITRARY MOMENTUM TRANSFER. Schucan, Thomas H. (Yale Univ., New Haven). Contract AT(30-1)-2726. Phys. Rev.; 188: 1520-30(20 Dec 1969).

A partial-wave calculation of inelastic electron scattering from nuclei is carried out analytically to second order in $\alpha Z$. The calculation is performed in a model-independent way, and it is therefore possible to display explicitly the connection between the differential cross section and the transition charge, as well as the ground-state charge distribution. Inelastic monopole cross sections are derived for both high and low energies and for arbitrary momentum transfers. The results are compared with the results of exact numerical calculations for given nuclear models. Good agreement is found for medium-heavy ($Z = 38$) and heavy ($Z = 80$) nuclei. It is also found that our results agree with the results of a WKB approximation, which has been obtained for a simple nuclear model and for high momentum transfer. (auth)

15960 PARTIALLY CONSERVED AXIAL-VECTOR CURRENT AND MESONIC-EXCHANGE EFFECTS IN NUCLEAR BETA DECAY. Blin-Stoyle, R. J. (Univ. of Sussex, Brighton, Eng.). Phys. Rev.; 188: 1540-1(20 Dec 1969).

The size of mesonic-exchange effects in nuclear $\beta$ decay are compared with the value given by the theory of partially conserved axial-vector current in the light of new experimental data. It is concluded that, allowing for the experimental and theoretical uncertainties, there is no violent disagreement. (auth)

15961 METHOD OF COMPLEX COORDINATES FOR THREE-BODY CALCULATIONS ABOVE THE BREAKUP THRESHOLD. Nuttall, J.; Cohen, H. L. (Texas A and M Univ., College Station). Phys. Rev.; 188: 1542-4(20 Dec 1969).

A method is proposed for calculating elastic and inelastic three-particle scattering amplitudes in the breakup region using a coordinate-space variational approach, with each coordinate multiplied by a complex phase factor. The trial wave functions have relatively simple asymptotic forms. The method applies to short-range potentials analytic in coordinate space. A numerical example indicates that the method works well for two-particle scattering. (auth)

15962 STRENGTH OF PAIRING FORCE AND ENERGY GAP IN FINITE NUCLEI. Jain, M. C.; Waghmare, Y. R. (Indian Inst. of Tech., Kanpur, India). Phys. Rev.; 188: 1568-73(20 Dec 1969).

Energy-gap calculations were made for the realistic Yale–Shakin interaction and a phenomenological $\delta$-function interaction of the type $J\delta(r)$, where J is the force strength. The results are found to agree fairly well, showing that they are independent of the detailed form of the interaction. (auth)

15963 NUMBER-CONSERVING APPROXIMATION TO THE SHELL MODEL. Gambhir, Y. K. (International Centre for Theoretical Physics, Trieste, Italy); Rimini, A.; Weber, T. Phys. Rev.; 188: 1573-82(20 Dec 1969).

The broken-pair-approximation (BPA) formalism is presented in complete form for the description of the nuclear properties of medium and heavy spherical nuclei. Starting from an approximate ground state of even nuclei having BCS-type pair distribution in the valence shells, the model Hilbert space is constructed by replacing one, two, ... pairs in the assumed approximate ground state by arbitrary two, four, ... particle configurations. The BPA states for odd-mass nuclei are obtained by coupling the odd nucleon to zero-, one-, ... broken-pair states. It is shown that the Hilbert spaces spanned in the projected quasiparticle theories and in the BPA are the same in a certain limit, and that in practice these two formalisms are physically equivalent. The BPA is an improvement on the quasiparticle theories and is an approximation to the seniority shell model. All the relevant expressions for calculating energy matrices, transition rates, inelastic electron-scattering form factors, and spectroscopic factors for one- and two-nucleon transfer reactions are presented in a coherent form. The corresponding expressions for the case of first BPA are further elaborated and presented in a form suitable for numerical computation. (auth)

15964 VARIATIONAL PRINCIPLE AND SLATER'S GENERALIZED HARTREE–FOCK THEORY FOR NUCLEI. Kobe, Donald H. (North Texas State Univ., Denton). Phys. Rev.; 188: 1583-9(20 Dec 1969).

The Hartree–Fock (HF) equations are generalized to take correlation into account, without replacing the exchange potential by a local approximation as Slater originally did. The nonlocal generalized HF equations are then obtained from a variational principle, that an energy functional be stationary at the true ground-state energy with respect to variations of the orbitals from orthogonality. The single-particle Hamiltonian is Hermitian, and there are no off-diagonal Lagrangian multipliers, in contrast to the multiconfiguration variational approaches. The best local approximation to the nonlocal equation gives essentially Slater's original equation, in which the average potential due to the other particles is given in terms of an integral over the product of the two-body potential and the true pair correlation function divided by the local density. (auth)

15965 SASAKAWA THEORY OF REACTIONS. Austern, N. (Univ. of Sydney. Univ. of Pittsburgh). Phys. Rev.; 188: 1595-1603(20 Dec 1969).

An iterative nonrelativistic theory of reactions is discussed. It generalizes Sasakawa's theory of elastic scattering, published in 1963. A key feature of the theory is its use of zero-order wave functions that allow self-consistent treatment of the asymptotic boundary conditions. This allows the theory to be applied both for inelastic scattering and for rearrangement. The analysis of rearrangement is a special case of the work by Efimenko, Zakhariev, and Zhigunov. The present paper emphasizes a zero-order wave function based on the "surface-$\delta$ model" of channel coupling. This wave function gives a zero-order theory (no iteration) that has the nature of a renormalized distorted-wave Born approximation. This zero-order theory may be adequate for most applications in nuclear physics. (auth)

15966 SHELL-MODEL THEORY OF ANALOG RESONANCES IN AN ISOSPIN BASIS. Payne, G. L.; Perez, J. D. (Univ. of Maryland, College Park). Contracts ORO-3765-21; GU 2061. Phys. Rev.; 188: 1611-17(20 Dec 1969).

Using the shell-model theory of nuclear reactions, it is explicitly shown how to treat isobaric analog resonance in an isospin basis. The Coulomb distortion of the continuum wave functions is included by performing a partial summation for the effective interaction. The corrections arising from the use of a shell-model

wave function for the parent are discussed. Finally, the coupling of the $\frac{3}{2}^-$ analog of the ground state of $^{49}$Ca to the anti-analog is calculated in order to illustrate the energy dependence and relative importance of the elastic and the nonelastic channels. (auth)

**15967** MIXED-PARITY HARTREE–FOCK CALCULATIONS FOR LIGHT NUCLEI USING REALISTIC FORCES. Ullah, Nazakat; Wong, S. S. M. (Univ. of Toronto). Phys. Rev.; 188: 1645-8(20 Dec 1969).

Mixed-parity Hartree–Fock calculations were performed on the nitrogen and oxygen isotopes using (1) a central Rosenfeld interaction, (2) a Rosenfeld-plus-an-appropriate-tensor interaction, and (3) bare Kuro–Brown matrix elements. It is shown that the results for the interactions (2) and (3) are fairly close. The gain for $^{16}$O is found to be larger than either of its isotopes A = 15 or 17. This is interpreted in terms of the energy gap between the occupied and the unoccupied Hartree–Fock orbitals. (auth)

**15968** SEPARABLE POTENTIALS UTILIZING RESONANT STATES. Fuller, R. C. (Univ. of Minnesota, Minneapolis). Contract AT(11-1)-1764. Phys. Rev.; 188: 1649-60(20 Dec 1969).

A method is developed for treating states corresponding to poles at unphysical energies in the two-particle S-matrix element for potential scattering. With this method, resonance and bound states can be considered on an equal footing. An inner product of such states is introduced, in terms of which these state are found to form an orthonormal set. An approximation method based on the construction of a separable potential using resonant and bound states is introduced for obtaining matrix elements of two-particle operators. Using the extended inner product, it is shown that the poles in the matrix elements of two-particle operators can be isolated by the approximation method. S-matrix elements and diagonal elements of the partial-wave Green's function for a square-well potential are calculated, using the approximation method, and compared with the exact quantities. Very good agreement is found. The approximation has application in the shell-model approach to nuclear reactions and to the three-body problem. (auth)

**15969** ADDENDUM TO THREE-PARTICLE CHANNELS IN NUCLEAR REACTION THEORY. Schmittroth, F.; Tobocman, W. (Case Western Reserve Univ., Cleveland). Phys. Rev.; 187: 1735-7(20 Nov 1969).

In the original article, a description of three-body channels in terms of two-cluster channel wave functions was proposed. It was stated in that article that each class of two-cluster channels could contribute simultaneously to the three-particle flux. This conclusion was based on the absence of any apparent reason for excluding contributions from any class of two-cluster channels. However, it is shown here that, in fact, only one two-cluster channel can contribute to the amplitude for a given three-body final state when the channel radii are taken to be infinite, as may be done in some forms of reaction theory. (auth)

**15970** THEORY OF NUCLEAR LEVEL DENSITY FOR PERIODIC INDEPENDENT-PARTICLE ENERGY-LEVEL SCHEMES. Kahn, Peter B. (State Univ. of New York, Stony Brook); Rosenzweig, Norbert. Phys. Rev.; 187: 1193-1200(20 Nov 1969).

Accurate and perspicuous formulas are derived for the density of states of a degenerate system of any number of types of fermions moving in arbitrary periodic single-particle energy-level schemes. The results are of the standard form with the modification that the excitation energy is to be replaced by an "effective energy." The effective energy contains an additive correction which depends explicitly on the structure and ground-state occupation of the periodic level sequences. The spin-dependent level-density formula for two kinds of particles should be useful in the correlation of observed nuclear level densities with shell-model level sequences. The present work generalizes, unifies, and simplifies earlier treatments of related problems. (auth)

**15971** FOUR-HOLE-LINE DIAGRAMS IN NUCLEAR MATTER. Day, B. D. (Argonne National Lab., Ill.). Phys. Rev.; 187: 1269-1302(20 Nov 1969).

The Brueckner–Goldstone diagrams with four independent hole lines, which give the third term in the expansion for the ground-state energy of infinite nuclear matter, are enumerated. These diagrams are grouped in a natural way into 16 distinct classes. Only one of these classes (the four-body clusters) involves the solution of a four-body equation. Six classes require the solution of the three-body Bethe–Faddeev equations, and nine classes can be evaluated in terms of two-body matrix elements alone. Exact formal expressions are given for the contribution to the energy from each class of diagrams. In these expressions, all exchange diagrams are included, and all energy denominators are clearly defined. Numerical estimates are made for each class of diagrams, assuming the two-body interaction to be the Reid soft-core potential. The sum of all contributions is attractive and is about 0.6 to 1.6 MeV. Most of the uncertainty in this result is caused by omission of the tensor force in certain diagrams. The implications of these results for the convergence of the energy expansion are discussed. (auth)

**15972** TENMO-GENERAL TENSOR MOMENT POLARIZATION COMPUTER PROGRAM. Thornton, S. T. (Oak Ridge National Lab., Tenn.); Willard, H. B.; McCulloch, R. D.; Graben, H. W. Nucl. Instrum. Methods; 78: 328-30(1970).

A computer program for calculating the most general tensor moments of polarization has been developed. Tensor moments of outgoing particles from a two-body final state reaction are calculated explicitly in terms of the tensor moments of the initial state particles, the scattering or reaction matrices, and the energy and angles. (auth)

**15973** A CONTRIBUTION TO THE THEORY OF THE RADIATIVE NUCLEON CAPTURE FROM DEUTERONS. Erdas, F. (Univ., Cagliari, Italy); Milani, C.; Seatzu, S.; Pompei, A. Nuovo Cim.; 64B: 390-405(11 Dec 1969).

A general discussion is given for the radiative nucleon-deuteron capture to form a three-body system. It is shown that the interaction between the nucleon and the deuteron at threshold is extremely relevant whatever model is used to describe the three- and two-body systems. The correction due to this interaction is evaluated using the dispersive approach. (auth)

**15974** THREE-NUCLEON PROBLEM. Amado, R. D. (Univ. of Pennsylvania, Philadelphia). Ann. Rev. Nucl. Sci.; 19: 61-98(1969).

A detailed review on the three-nucleon problem is presented. Bound states, scattering and breakup, and electromagnetic and weak probes are analyzed in depth. (227 references). (J.W.R.)

**15975** COUPLED-CHANNEL APPROACH TO NUCLEAR REACTIONS. Tamura, Taro (Univ. of Texas, Austin,). Ann. Rev. Nucl. Sci.; 19: 99-138(1969).

The formulation of the coupled channel method for studying nuclear reactions is briefly reviewed. The use of coupled-channel calculations in fitting scattering data on both spherical and deformed nuclei is illustrated. The application of coupled-channel calculations to problems other than straightforward scattering problems is also described. Some suggestions and predictions on the scope of future work are presented. (169 references). (J.W.R.)

**15976** NUCLEAR MASS RELATIONS. Garvey, G. T. (Oxford Univ.). Ann. Rev. Nucl. Sci.; 19: 433-70(1969).

The present state of equations proposed to relate the observed energy differences between ground states of neighboring nuclei and between levels in isospin multiplets is surveyed. Mass laws assuming charge independence or charge symmetry for the nuclear interactions and mass laws relating the energies of states differing in their specific nuclear interactions are reviewed. (75 references). (J.W.R.)

**15977** COULOMB ENERGIES. Nolen, J. A. Jr. (Univ. of Maryland, College Park). Ann. Rev. Nucl. Sci.; 19: 471-526 (1969).

A review is presented consisting of a history of the interpretation of Coulomb energies, methods used in measuring Coulomb-energy differences, references to recent compilations of empirical Coulomb-energy differences, and references to techniques and empirical information on independently determined nuclear-charge radii. A simple model for the calculation of Coulomb-energy differences is presented and some possible correction terms are discussed. Some examples are given. (104 references). (J.W.R.)

**15978** MUONIC ATOMS AND NUCLEAR STRUCTURE. Wu, C. S. (Columbia Univ., New York). Ann. Rev. Nucl. Sci.; 19: 527-606(1969).

A review on the use of muonic atoms in nuclear structure research is presented. The production of muonic atoms and the experimental techniques for spectral measurements are discussed. The characteristic features of muonic atoms and their relation to nuclear properties are described. The current status of research and the outlook for the future are surveyed. (154 references). (J.W.R.)

**15979** DECOUPLING PARAMETER IN LIGHT NUCLEI. Bhatia, K. L.; De Takacsy, N. (McGill Univ., Montreal). Phys. Rev.; 187: 1347-50(20 Nov 1969).

The approximate-projection method of Das Gupta and Van-Ginneken is extended to include the calculation of the decoupling parameter for $K = \frac{1}{2}$ bands. The method is tested on the first positive- and negative-parity bands of $^{19}$F and is found to give

good results even when the strong-coupling model seems to fail. The validity of the formula for the decoupling parameter given by the strong-coupling model is explored. (auth)

15980 THE DISTRIBUTION OF LEVEL WIDTHS $\Gamma_n$ AND $\Gamma_\gamma$. Aldea, L.; Stadnicov, T. (Inst. of Atomic Physics, Bucharest). Stud. Cercet. Fiz.; 21: 661-718(1969). (In Rumanian).

Invariance conditions for the Hamiltonian of a physical system Hamiltonian matrix element distribution (orthogonal group, unitary group, symplectic group), level width distribution, correlation, experimental testing, and Rosenzweig's distribution are discussed. (auth)

15981 NONLOCAL FORCES AND HARTREE-FOCK CALCULATIONS. Hammann, T. F. (Laval Univ., Quebec); Ho-Kim, Q. Nuovo Cim.; 64B: 367-80(11 Dec 1969).

A new form of the two-body potential recently proposed was investigated for its possible applications in nuclear calculations. This nonsingular force, chosen for its success in fitting scattering phase shifts, saturates nuclear matter at the correct energy and density, and yields small second-order corrections. It can thus be applied with confidence to Hartree-Fock calculations of finite nuclei. The closed-shell nuclei $^{16}O$ and $^{40}Ca$ were studied and many of their basic properties were reasonably predicted. (auth)

15982 EFFECTIVE-INTERACTION THEORY OF NUCLEAR SPECTRAL RELATIONS. I. PARTICLE-HOLE RELATIONS. West, Bruce J.; Koltun, Daniel S. (Univ. of Rochester, N. Y.). Phys. Rev.; 187: 1315-28(20 Nov 1969).

A theory of the relation between particle-particle (pp) and particle-hole (ph) spectra is developed using the effective interaction of the Brueckner-Goldstone many-body theory. The shell-model relation of Pandya, Goldstein, and Talmi is shown to be an approximation to a more general many-particle relation. The main terms omitted by the shell-model pp-ph transformation are found to be of an effective three-body nature. The new theory is applied to the case of $^{42}Sc(pp)$ and $^{42}Sc(ph)$, and gives considerably better agreement with experiment than does the standard shell-model relation. For example, the root-mean-square deviation between the predicted and experimental levels of $^{42}Sc$ is 310 keV for the new theory, as compared to 580 keV for the shell-model relation. (auth)

15983 POTENTIAL IN AN ANALOG-STATE CALCULATION. Payne, G. L.; Perez, J. D.; MacDonald, W. M. (Univ. of Maryland, College Park). Phys. Rev.; 187: 1733-5(20 Nov 1969).

It is shown that proper handling of the single-particle potential and the inclusion of the 1p-0h component in the calculations of Beres and Divadeenam give an analog state with the expected structure. The resulting $^1/_2^+$ analog state in $^{89}Y$ is found to have an analog spin impurity of 0.3% and an isospin impurity of approximately 2%. (auth)

15984 INSTABILITY OF A SPHERICAL CONFIGURATION IN THE SIMPLEST NUCLEAR MODEL. Nosov, V. G. Zh. Eksp. Teor. Fiz.; 57: 1765-77(Nov 1969). (In Russian).

It is shown that small deformations of some homogeneous bodies with a definite type of energy spectrum are accompanied by a macroscopic quantum effect. A complete analytic solution of the problem is presented for the concrete model of an ideal fermi gas. In this case the change in volume energy of the body due to deformation of the spherical surface is negative. The results are in qualitative agreement with the data on static and dynamic deformations of atomic nuclei. The physical nature of the phase transition in nuclei is discussed. (auth)

15985 SEMI-EMPIRICAL MASS FORMULA AND NUCLEAR RADII. Rook, J. R. (Oxford Univ.). Phys. Lett.; 30B: 607-8 (22 Dec 1969).

The semi-empirical mass formula is extended to include different radii for the proton and neutron distributions. By minimizing the energy, the radii are determined. The model predicts that the proton radius equals the neutron radius for all stable nuclei and that this radius has an accurate $A^{\frac{1}{3}}$ dependence. (auth)

15986 ORTHOGONALITY PROPERTIES OF THE COUPLED EQUATIONS FOR REARRANGEMENT COLLISIONS. Hahn, Y. (Univ. of Connecticut, Storrs). Phys. Lett.; 30B: 595-7(22 Dec 1969).

The orthogonality properties required for a rigorous formulation of the coupled equations method for reactions involving particle exchanges and rearrangements are presented without the explicit use of multichannel projection operators. (auth)

15987 LOCALIZED OSCILLATOR EXPANSIONS OF NUCLEAR TWO-BODY WAVE FUNCTIONS. Hartt, K.; Kirwan, D. (Univ. of Rhode Island, Kingston). Phys. Lett.; 30B: 591-4 (22 Dec 1969).

Harmonic oscillator expansions are applied to two-body systems simulating the deuteron, triton and alpha particle. Convergence rates in energies and wave functions can be significantly improved when the expansions are localized by first subtracting an approximate asymptotic wave function. (auth)

15988 ON THE CONVERGENCE OF MARUMORI'S BOSON EXPANSION FOR PAIRING VIBRATIONS. Kleber, M. (Technische Hochschule, Munich). Phys. Lett.; 30B: 588-90(22 Dec 1969).

It is demonstrated analytically for a two-level model with pairing force that Marumori's method converges rapidly if one uses the idea of pairing vibrations. The approximation of Sørensen and the broken-pair approximation are compared with Marumori's boson expansion. (auth)

15989 NUCLEAR BREMSSTRAHLUNG AS A TEST OF THE OPTICAL MODEL. Henley, E. M.; Richards, F. C. (Univ. of Washington, Seattle). Phys. Lett.; 30B: 585-7(22 Dec 1969).

Nuclear optical potential matrix elements occur off-the-energy shell in standard nuclear reaction analyses. The usefulness of bremsstrahlung for investigating such matrix elements is examined. Contributions from virtual nuclear excitations are included. (auth)

15990 APPLICATION OF ELEMENTARY PARTICLE TREATMENT OF NUCLEI TO SCATTERING OF PIONS BY NUCLEI. Srinivasa Rao, K.; Ranganathan, N. R.; Sundaram, A. (MATSCIENCE, Madras). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 23-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

It is shown that the s-matrix element for pion-nucleus scattering can be related to the nuclear vector matrix element using the PCAC hypothesis and the algebra of currents. By treating the nucleus as an elementary particle, all the complexity of nuclear structure is imbedded in form factors which are available from electron-nucleus scattering. (J.W.R.)

15991 DISPERSION RELATION FOR THE EQUIVALENT LOCAL OPTICAL MODEL POTENTIAL. Ahmad, I.; Rahman Khan, M. Z. (Aligarh Muslim Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 62-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The dispersion relation for an equivalent local optical-model potential is derived. It is indicated that the intrinsic energy dependence and the energy dependence arising from the non-locality of the realistic potential are important. This implies that the non-local optical potentials with energy independent parameters would be suitable only for a limited energy region. (J.W.R.)

15992 EFFECTS OF SHORT-RANGE CORRELATIONS IN NUCLEI ON SOME REACTION PROCESSES. Devanathan, V. (Univ. of Madras). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 67-71(1968).

Short-range correlations are introduced into the shell model by the use of a unitary operator on the shell model wave function. The two-body term that arises from nuclear correlations in some reaction processes is evaluated. (J.W.R.)

15993 P-WAVE NEUTRON CAPTURE CROSS SECTIONS AT 24 keV. Chaubey, A. K.; Sehgal, M. L. (Aligarh Muslim Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 82-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

S-wave neutron capture cross sections at 24 keV were calculated for N = 20 to 120 nuclei using Breit-Wigner theory. These cross sections were then subtracted from experimental capture cross sections at 24 keV to obtain the p-wave capture cross sections. The results indicate a magic number effect in the p-wave capture cross section. (J.W.R.)

15994 ANALYSIS OF NUCLEAR SCATTERING THROUGH POLES OF THE S-MATRIX IN THE k-PLANE. Shanta, R. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 101-4(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The elastic scattering of $\alpha$-particles by $^{12}C$ is analyzed through the polology of the s-matrix in the complex momentum plane. The differential cross sections are calculated by assuming a product representation for the nuclear part of the s-matrix. The only pa-

rameters needed are the levels and widths of the $^{16}O$ compound nucleus and the radius of the $^{12}C$ nucleus. (J.W.R.)

15995 SINGLE PARTICLE EFFECTS IN FAST (n,2n) REACTIONS. Chatterjee, Swapna; Chatterjee, Aparesh (Calcutta Univ. Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 105-9 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

A re-evaluation of the experimental data on fast (n,2n) cross sections has shown effects associated with nucleon numbers. Three separable distinct trends are discussed. Effects are described which are associated with the quantity N-Z, with residual isotopes and isotones, and with shell-closure regions. (J.W.R.)

15996 ENERGY LEVEL CALCULATIONS FOR LIGHT AND INTERMEDIATE NUCLEI USING AN EFFECTIVE INTERACTION. Joshi, K. P. (Indian Inst. of Tech., Kanpur, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 158-61 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

A phenomenological effective potential is derived which simulates the Yale potential but is easier to handle computationally. The parameters are determined by demanding the best fit to the Yale matrix elements. As a test of this potential, the matrix elements for the 0f-1p region are calculated and compared with other calculations. (J.W.R.)

15997 NUCLEAR MATTER CALCULATIONS WITH HARD-CORE AND LONG RANGE POTENTIALS. Khanna, K. M. (Dibrugarh Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 183-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

A realistic calculation is performed for the normal-superfluid phase transition temperature of an extended system of alpha particles interacting by a hard-core and a long-range potential. The results suggest that the transition temperature is not very sensitive to changes in the interaction potential so long as the nature of the potential is unaltered. (J.W.R.)

15998 GEOMETRIC FOUNDATIONS OF NUCLEAR SHELL STRUCTURE. Ramanna, R.; Jyothi, S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 245-56(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The characteristics of the Schroedinger equations for a nuclear system may be determined by the choice of an appropriate manifold of the exterior differential system associated with partial differential equations. It is shown that this manifold corresponds exactly to the many-body neutron and proton potentials commonly assumed in nuclear theory. A shell structure is evident when the method is applied to a many-nucleon system. (J.W.R.)

15999 EFFECTIVE NUCLEON-NUCLEON INTERACTIONS IN NUCLEAR MATTER. Pandharipande, V. R. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 265-8(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Variational calculations were performed for the binding energies of $^4He$, $^{16}O$, $^{40}Ca$, and infinite nuclear matter in order to determine the parameters for three similar effective density-dependent nucleon-nucleon interactions. Parameters were found which gave good agreement with experiment in all cases. (J.W.R.)

16000 CALCULATION OF THE DENSITY DISTRIBUTION IN NUCLEI. Pandharipande, V. R. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 269-72(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The density distributions in N = Z nuclei with A = 40, 100, and 200 were calculated by the variational method using an effective density-dependent interaction. The radii, surface thicknesses, and central densities were obtained in good agreement with experimental data for these mass numbers. (J.W.R.)

16001 SYSTEMATICS OF K-ISOMERISM. Rajput, M. S.; Sehgal, M. L. (Aligarh Muslim Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 273-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The available experimental data on K-forbidden nuclear transitions were compiled to study the systematics of K-isomerism. The K-forbiddenness is correlated with the hindrance factor. (J.W.R.)

16002 METHOD FOR FAST CONVERGENCE OF t-MATRIX. Mukherjee, S.; Satpathy, R. K. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 284-8(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

An expansion for the reaction t-matrix of Brueckner is derived in terms of potential differences. The purpose is to perform a calculation to good enough accuracy that the first order result is sufficient. The binding energy of nuclear matter is calculated as an example. (J.W.R.)

16003 PROBABILITIES OF ELECTRIC QUADRUPOLE TRANSITIONS IN ODD DEFORMED NUCLEI. Begzhanov, R. B.; Isakov, B. I.; Sharipov, Sh. Sh. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk Uzb. SSR, Ser. Fiz.-Mat. Nauk; No. 5, 41-6(1969). (In Russian).

The influence of deformed shape of odd nuclei on the probabilities of E2 transitions inside of the initial abnormal rotational-single particle band and transitions between the first abnormal rotational single-particle and the basic rotational single-particle band was studied. Tabulated data are given on the spin and energy levels of $^{245}Cm$ and $^{159}Tb$ nuclei. (R.V.J.)

16004 REPULSIVE CORE OF NUCLEAR FORCES. Otsuki, Shoichiro (Kyushu Univ., Fukuoka). Progr. Theor. Phys. (Kyoto), Suppl; No. 42, 39-106(1968).

The present knowledge on the repulsive core of nuclear forces is summarized. The phenomenological aspects of the repulsive core are reviewed. Information on the repulsive core obtained from high-energy N-N interactions is surveyed. The theories on the origin of the repulsive core are examined in detail. (180 references) (J.W.R.)

16005 POTENTIAL METHODS FOR THE PREPARATION AND EXAMINATION OF NEW ISOTOPES. Fenyes, Tibor (Nuclear Research Inst., Debrecen, Hungary). Magy. Fiz. Foly.; 17: 1-38(1969). (In Hungarian).

Although more than 1500 isotopes are known today, our knowledge of the structure of the nucleus is limited because these isotopes lie near the stable nuclei, within a narrow proton/neutron band. Introduction of new experimental devices in physics render it increasingly possible to prepare and to identify very short half-life isotopes; it may be anticipated that hundreds and even thousands of new isotopes will be prepared. The potential methods of preparation and study are reviewed. The special nuclear matter with a structure approaching the pure-neutron or pure-proton constitution may lead to the discovery of novel effects. Spallation and heavy-ion reactions are the most efficient methods for obtaining strongly neutron-deficient light and heavy nuclei, respectively; the $(\gamma,xn)$ reaction is also suited for this purpose. Within the 35 to 60 range high neutron-excess nuclei may be obtained by thermal-neutron induced fission of heavy elements, such as U and Th; at Z near 65, fission by high-energy particles and the (p,2p) reaction are competitive with the thermal fission method. Beyond Z = 75 it is difficult to create such nuclei, except by underground nuclear explosions. The methods used for the transfer of reaction products from the target to the measuring system are examined together with techniques for identifying the new isotopes. The already operating and planned on-line mass separators are briefly reviewed. (99 references). (TTT)

16006 THEORY OF COLLECTIVE MOTION IN NUCLEI. Klein, Abraham (Univ. of Pennsylvania, Philadelphia). Lect. Theor. Phys.; 11-B: 1-53(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727-(Pt.3).

The theoretical developments leading to a unification of the shell and collective nuclear models are discussed. The development of the generalized Hartree-Fock method for treating the collective properties of nuclei is traced. (J.W.R.)

16007 REACTION-MATRIX THEORY OF NUCLEI: AND OTHER HARD-CORE FERMI LIQUIDS. Brandow, B. H. (Cornell Univ., Ithaca, N. Y.). Lect. Theor. Phys.; 11-B: 55-155 (1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727-(Pt.3).

The formal aspects of progress toward relating nuclear matter theory and general nuclear structure are described. The development of the Brueckner-Bethe-Goldstone formalism is traced in detail. A new and comparatively elementary method for the deri-

vation of the linked cluster expansions is presented. The results are applicable to all open-shell systems. A program of partial summations suitable for nuclear systems is given. (J.W.R.)

16008 THE GROUND STATE OF HOMOGENEOUS NUCLEAR MATTER AND THE FOUNDATION OF THE NUCLEAR SHELL MODEL. Coester, F. (Argonne National Lab., Ill.). Lect. Theor. Phys.; 11-B: 157-86(1969).

From Conference on Quantum Fluids and Nuclear Matter, Boulder, Colo. See CONF-680727-(Pt.3).

Topics included are: the states of low-density fermion systems, the stationary states of homogeneous nuclear matter, solutions for soft potentials, solutions for hard potentials, the ground state of a closed-shell nucleus, and the shell-model problem. (J.W.R.)

# REACTOR TECHNOLOGY

## Commercial Power Reactors

*Refer also to abstracts 14034, 14057, 14142, 14207, 14216, 14217, 14246, and 14339.*

**16009** (AE-376) EXPERIMENTAL AND THEORETICAL DYNAMIC STUDY OF THE AGESTA NUCLEAR POWER STATION. Bliselius, P.-A.; Vollmer, H.; Akerhielm, F. (Aktiebolaget Atomenergi, Studsvik (Sweden)). Dec 1969. 39p. Dep. CFSTI (U. S. Sales Only).

A final review of all dynamic investigations of the Ågesta nuclear power station is presented. Transfer functions and step responses were measured by perturbations in reactivity and steam load. Three methods were used for transfer function measurements: step functions, trapeze waves and multifrequency functions based on the pseudo-random binary sequence (PRBS). Results are compared. The dynamic experiments carried out at the Ågesta nuclear power station demonstrate both the inherent stability and the safety of this plant. 18 references. (auth)

**16010** (BARC-423) THEORETICAL REACTOR PHYSICS STUDIES. Annual Progress Report, 1968. Rastogi, B. P. (Bhabha Atomic Research Centre, Bombay (India)). 1969. 17p. Dep. CFSTI (U. S. Sales Only).

A brief discussion of the work done in the Theoretical Physics Section of Reactor Engineering Division during the year 1968. Work done in the fields of heavy water reactors, water reactors, fast reactors, molten salt breeders, reactor evaluation and reactor theory is outlined. (auth)

**16011** (CEA-N-1242) EL 4: BALANCE OF REACTIVITY TO POWER. REACTOR "EVOLUTION". Goix, Noelle; Chabrillac, Marcel (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Jan 1970. 83p. (In French). Dep. CFSTI (U. S. Sales Only).

The results of neutronic tests performed on EL 4 reactor operating at power are collected and comparisons are made with calculations performed under the same conditions. In the first part, the effects of soluble poison, control rods, Xe, Sm and Rh poisoning, and heavy water temperature are studied. Temperature or power coefficients of the reactor are deduced from a comparison of two stable states: on power and cold state. The second part deals with the study of fuel evolution, from the startup till a shutdown at 64 equivalent days on power. This study is made by means of cold reactivity balances, of an experiment at stable operation and of flux maps. 19 references. (auth) (France)

**16012** (DOCKET-1153-6) HALLAM NUCLEAR POWER FACILITY. Environmental Monitoring Program. Quarterly Report No. 34, October-December 1969. (Consumers Public Power District, Hallam, Nebr.). 30 Jan 1970. 8p. Dep. CFSTI.

**16013** (DOCKET-1153-7) HALLAM NUCLEAR POWER FACILITY. Environmental Monitoring Program. Quarterly Report No. 30, October-December 1968. (Consumers Public Power District, Hallam, Nebr.). 17 Feb 1969. 3p. Dep. CFSTI.

**16014** (DOCKET-1153-8) HALLAM NUCLEAR POWER FACILITY: CERTIFICATION OF FINAL SITE RADIATION SURVEY. (Isotopes, Inc., Westwood, N. J.). 23 Jan 1970. 69p. (WL-9885-201). Dep. CFSTI.
For Consumers Public Power District, Hallam, Nebr.

**16015** (DOCKET-1155-19) LA CROSSE BOILING WATER REACTOR. Monthly Operating Report, November 1969. (Dairyland Power Cooperative, La Crosse, Wis.). 9 Feb 1970. 28p. Dep. CFSTI.

**16016** (DOCKET-1155-20) LA CROSSE BOILING WATER REACTOR. Failure of Diesel Fire Pump 1A to Start for Monthly Test. Incident Report No. DPC 70-2. (Dairyland Power Cooperative, La Crosse, Wis.). 11 Feb 1970. 2p. Dep. CFSTI.

A starting failure of the diesel in the five protection water system of the La Crosse Boiling Water Reactor is described. Incident evaluation, corrective action taken, and results of corrective action are summarized. (M.L.S.)

**16017** (DOCKET-50016-31) ENRICO FERMI ATOMIC POWER PLANT, [UNIT 1]. [Operations] Report, October 1969. (Power Reactor Development Co., Detroit, Mich.). 6 Feb 1970. 12p. (PRDC-EF-74). Dep. CFSTI.

**16018** (DOCKET-50016-32) ENRICO FERMI ATOMIC POWER PLANT, UNIT 1. License No. DPR-9. Technical Specifications Change No. 19, Appendix A. (Power Reactor Development Co., Detroit, Mich.). 10 Feb 1970. 50p. Dep. CFSTI.

The complete Technical Specifications for the restart of the Fermi Fast Breeder Reactor are given. Changes to the technical specifications reflect the addition of protective devices and provide better definition of administrative requirements for operation. (M.L.S.)

**16019** (DOCKET-50029-112) YANKEE NUCLEAR POWER STATION. Operation Report No. 109, January 1970. (Yankee Atomic Electric Co., Westboro, Mass.). 20 Feb 1970. 7p. Dep. CFSTI.

**16020** (DOCKET-50133-26) HUMBOLDT BAY POWER PLANT, UNIT NO. 3. Operations Report, July 1-December 31, 1969. (Pacific Gas and Electric Co., San Francisco, Calif.). 10 Feb 1969. 19p. Dep. CFSTI.

**16021** (DOCKET-50155-18) [BIG ROCK POINT NUCLEAR PLANT]. Power Reactor High Performance $UO_2$ Program. Progress Report No. 8, July 1-September 30, 1968. (General Electric Co., San Jose, Calif. Nuclear Fuels Dept.). Oct 1968. Contract AT(04-3)-189. 45p. Dep. CFSTI.
For Consumers Power Co., Jackson, Mich.

BIG ROCK POINT POWER REACTOR — fuel elements in, characteristics of failed uranium oxide ($UO_2$) centermelt — fuel elements in, results of post-irradiation testing and examination of uranium oxide ($UO_2$) centermelt (M.L.S.)

**16022** (DOCKET-50155-23) [BIG ROCK POINT NUCLEAR PLANT]. Re-evaluation of Potential Loss of Coolant Accidents. (Consumers Power Co., Jackson, Mich.). 9 Feb 1970. 43p. Dep. CFSTI.

Emergency core cooling provisions for the Big Rock Point Power Reactor are evaluated. The postulated coolant-pipe-rupture incidents are defined; the coolant loss accident analysis includes both blowdown and heat up for both top and bottom breaks. Containment sphere and primary piping design parameters are tabulated. Details and data from the analyses are shown graphically. (M.L.S.)

**16023** (DOCKET-50155-24) [BIG ROCK POINT NUCLEAR PLANT]. High Primary Coolant Conductivity Incident. [Unusual Occurrence Report]. (Consumers Power Co., Jackson, Mich.). 20 Feb 1970. 2p. Dep. CFSTI.

A high primary coolant conductivity incident in the Big Rock Point Power Reactor is described. Resins in the coolant cleanup demineralizer had been decomposed by high temperature. The alarm and pump trip circuit, which operates off the coolant-conductivity recorder, had failed because the contacts for the recorder did not work with the recorder door closed. Maintenance and corrective action are described. (M.L.S.)

**16024** (DOCKET-50171-23) [PEACH BOTTOM ATOMIC POWER STATION, UNIT 1]. Provisional Operating License No. DPR-12, Amendment 2. (Division of Reactor Licensing (AEC), Washington, D. C.). 19 Feb 1970. 4p. Dep. CFSTI.
For Philadelphia Electric Co., Pa.

Authority for doubling the amounts of $^{235}U$, $^{238}U$, and $^{232}Th$ which are on-site at the Peach Bottom Power Reactor, Unit 1 is given. Permission to double the amount of polonium is also recorded. The complete reissue of the provisional operating license is included. (M.L.S.)

**16025** (DOCKET-50213-30) [CONNECTICUT YANKEE ATOMIC POWER PLANT]. Report of Loss of Off-Site Power, July 15, 1969. (Connecticut Yankee Atomic Power Co., Boston, Mass.). 24 Jul 1969. 3p. Dep. CFSTI.

**16026** (DOCKET-50213-31) [CONNECTICUT YANKEE ATOMIC POWER PLANT]. Operation Report No. 70-1, January 1970. (Connecticut Yankee Atomic Power Co., Haddam). 24 Feb 1970. Contract AT(30-1)-3250. 10p. (NYO-3250-44). Dep. CFSTI.

**16027** (DOCKET-50237-21) DRESDEN NUCLEAR POWER STATION, UNIT NO. 2. Proposed Technical Specifications. (Commonwealth Edison Co., Chicago, Ill.). 9 Sep 1968. 126p. Dep. CFSTI.

The complete technical specifications for the Dresden Power Reactor, Unit 2 are presented. Safety limits, limiting conditions for operation, surveillance requirements, design features, and administrative controls are detailed. (M.L.S.)

**16028** (DOCKET-50238-57) N. S. SAVANNAH. Facility License No. NS-1, Amendment 6. (Division of Reactor Licensing (AEC), Washington, D. C.). 19 Feb 1970. 4p. Dep. CFSTI.

For First Atomic Ship Transport, Inc., New York.

A change in quantity and type of byproduct material for the N. S. Savannah is described. (M.L.S.)

**16029** (DOCKET-50244-30) BROOKWOOD NUCLEAR STATION, UNIT NO. 1. Fourth Supplement to Preliminary Facility Description and Safety Analysis Report, [Amendment 6]. (Rochester Gas and Electric Corp., N. Y.). 4 Oct 1966. 134p. Dep. CFSTI.

Name changed later to Robert Emmett Ginna Nuclear Power Plant, Unit 1.

Design data for the Robert E. Ginna Power Reactor, Unit 1 are detailed. The tendon design, surveillance program, and provisions for corrosion protection are described. Responsibilities and procedures for quality control are delineated. Testing and test instrumentation are discussed. Model testing is described. (M.L.S.)

**16030** (DOCKET-50245-25) MILLSTONE NUCLEAR POWER STATION, UNIT 1. [Preliminary Safety Analysis Report], Amendment 23. (Connecticut Light and Power Co., Hartford, Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). 11 Feb 1970. 17p. Dep. CFSTI.

The low-pressure-coolant injection (LPCI) and core spray systems components for the Millstone Point Power Reactor, Unit 2 are tabulated; effects of 203°F operating conditions on these components are considered. Forces and moments on the LPCI heat exchanger nozzles are tabulated. Manufacturers data on the heat exchanger tube sheet are given. (M.L.S.)

**16031** (DOCKET-50245-26) [MILLSTONE NUCLEAR POWER STATION, UNIT 1]. [Preliminary Safety Analysis Report], Amendment 24. (Connecticut Light and Power Co., Hartford, Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). 13 Feb 1970. 14p. Dep. CFSTI.

Consolidated income statements for the Northeast Utilities and Subsidiaries are presented for the 1968-1969 interval. Income statements and balance sheets are also included for the various member companies. (M.L.S.)

**16032** (DOCKET-50250-16) TURKEY POINT PLANT, UNIT NO. 3. Soniscope Investigation of the Containment Mat. (Florida Power and Light Co.). 9 Feb 1970. 9p. Dep. CFSTI.

Test results of the soniscope investigation of the Turkey Point Power Reactor, Unit 3 containment mat are detailed. Results of horizontal measurement of sonic pulse velocity through the containment mat are shown for various elevations; data are also tabulated. (M.L.S.)

**16033** (DOCKET-50255-24) [PALISADES PLANT]. [Preliminary Safety Analysis Report], Amendment 20. (Consumers Power Co., Jackson, Mich.). 20 Feb 1970. 35p. Dep. CFSTI.

Some results of calibration of containment system equipment for the Palisades Power Reactor are tabulated. 1969 financial status of the Consumers Power Company, owners of the Palisades plant, is detailed. A copy of the insurance agreement with NELIA is included. (M.L.S.)

**16034** (DOCKET-50261-21) H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2. [Preliminary Safety Analysis Report], Amendment 15. (Carolina Power and Light Co., Raleigh, N. C.). 6 Feb 1970. 118p. Dep. CFSTI.

Revised and additional information on the H. B. Robinson Power Reactor, Unit 1 is given. The instrumentation to be used for detection of thermal shield motion or vibration is described. Seismic design of Class I equipment is discussed, seismic stresses and loads used in the design are tabulated. Details relating to the static analyses of the piping systems are given; piping data, pressure stresses, and weight stresses are tabulated for the piping for all systems. Safety factors of seismic supports for the piping are given; the methods used in seismic analyses for the piping for all systems are outlined. Results of cooling system piping analyses are detailed. Procedures for setting turbine-trip set points are given. The component environmental testing program is described. Equipment required for post-accident operation, and, therefore, to be qualification tested is tabulated; test environmental conditions of pressure and temperature are shown graphically; gamma dose levels inside the containment vessel are also shown. Electrical penetrations of the containment vessel are discussed. Load schedules for diesel generators for loss of offsite power are tabulated. Results of multirod burst tests of typical fuel elements are given. (M.L.S.)

**16035** (DOCKET-50261-22) H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2. [Preliminary Safety Analysis Report, Amendment 16]. (Carolina Power and Light Co., Raleigh, N. C.). 19 Feb 1970. 6p. Dep. CFSTI.

Interim financial statements for the year ending 31 December 1969 of the Carolina Power and Light Company, owners of the H. B. Robinson Power Reactor, Unit 2, are presented. Operating expenses for the 1970-1975 period and permanent shutdown and retirement for the Robinson plant are estimated. (M.L.S.)

**16036** (DOCKET-50261-23) H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2. [Preliminary Safety Analysis Report], Amendment 17. (Carolina Power and Light Co., Raleigh, N. C.). 24 Feb 1970. 23p. Dep. CFSTI.

Qualifications and responsibilities of personnel at the H. B. Robinson Power Reactor, Unit 2 are listed. Requirements for operations shift teams are discussed. (M.L.S.)

**16037** (DOCKET-50266-15) POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2. Environmental Radiation Survey. Annual Report, July 1968-June 1969. (Wisconsin Electric Power Co., Milwaukee. Wisconsin Michigan Power Co., Appleton, Wis.). 26 Jan 1970. 24p. (DOCKET-50301-12). Dep. CFSTI.

**16038** (DOCKET-50266-17) POINT BEACH NUCLEAR PLANT, UNITS NO. 1 AND 2. Final Facility Description and Safety Analysis Report, Amendment 3. (Wisconsin Electric Power Co., Milwaukee. Wisconsin Michigan Power Co., Appleton, Wis.). 19 Feb 1970. 151p. (DOCKET-50301-14). Dep. CFSTI.

Details relating to the Point Beach Power Reactor, Units 1 and 2 containment air recirculation system are given. Startup surveillance and pre-core loading functional testing are discussed. Seismic design criteria for all Class I components, systems, and structures are specified; loading conditions and stress limits are tabulated; results of seismic analyses are shown graphically. Compliance of the coolant system temperature sensors with IEEE criteria is considered. Equilibrium secondary coolant activity is tabulated for proposed technical specification limits for primary to secondary leak rate and primary coolant activity; data are shown graphically. Responsibility and authority for startup operations are delineated. Off-site consequences of a steam line break accident are evaluated. (M.L.S.)

**16039** (DOCKET-50277-9) PEACH BOTTOM ATOMIC POWER STATION, [UNITS 2 AND 3]. Environs Radiation Monitoring Program. Operational Report No. 8, January 1-December 31, 1967. (International Chemical and Nuclear Corp., Pittsburgh, Pa. Nuclear Science Div.). Jul 1968. 78p. (DOCKET-50278-9; NSEC-139). Dep. CFSTI.

For Philadelphia Electric Co., Pa.

**16040** (DOCKET-50293-25) PILGRIM NUCLEAR POWER STATION. [Preliminary Safety Analysis Report], Amendment 13. (Boston Edison Co., Mass.). 16 Feb 1970. 164p. Dep. CFSTI.

A complete set of proposed Technical Specifications for the Pilgrim Power Reactor is presented. The in-service inspection program is detailed. Revised and additional pages for the FSAR are also included. (M.L.S.)

**16041** (DOCKET-50305-7) [KEWAUNEE NUCLEAR POWER PLANT]. Environmental Radiation Survey. Annual Report, July 1968-June 1969. (Wisconsin Public Service Corp., Green Bay). 26 Jan 1970. 24p. Dep. CFSTI.

**16042** (DOCKET-50329-7) MIDLAND PLANT, [UNITS 1 AND 2]. Preliminary Safety Analysis Report, Amendment 5. (Consumers Power Co., Jackson, Mich.). 10 Nov 1969. 599p. (DOCKET-50330-7). Dep. CFSTI.

Revised population distributions for the Midland Power Reactor, Units 1 and 2 site are shown. The diffusion models for site dispersion factors are discussed. Designs and characteristics of the containment vessel prestressing tendons are described. Load combination equations for the design of Class I concrete structures are listed. Detailed procedure specifications for mechanical splicing of deformed concrete reinforcing bars are given. Independence of redundant protection channels for the engineered safeguards is discussed; schematics are included for the safety injection system and plant emergency and auxiliary systems. The assumptions used in analysing the radiological consequences of postulated coolant loss accidents are detailed. The use of spray additives in Emergency Core Cooling Systems (ECCS) is summarized. Proposed technical specifications are included. The proposed research and development programs at the Midland plant are discussed. The preoperational environmental radiation monitoring program is detailed. Details of the flood and low water conditions are analyzed for the Midland site. Reactor vessel design and operational sur-

veillance is discussed. Methods used for design of the containment structure and Class I equipment are described; simplified physical models used in seismic analyses of the reactor building are shown; seismic damping values are tabulated. The design of the vent valves in the core support shield is analyzed. Post-accident functioning of the ECCS is evaluated. Rights-of-way; number, size, and type of towers per right-of-way; and number of circuits per tower connecting the Midland plant are detailed. A failure mode analysis of offsite and onsite electric power systems is listed. Energy distributions within the reactor building prior to coolant loss accidents are tabulated. Detailed information on the soils settlement calculations for the Midland site is given. (M.L.S.)

**16043** (DOCKET-50329-9) [MIDLAND PLANT, UNITS 1 AND 2]. [Preliminary Safety Analysis Report], Amendment 7. (Consumers Power Co., Jackson, Mich.). 2 Feb 1970. 100p. (DOCKET-50330-9). Dep. CFSTI.

Soil analysis for the site is presented. The effects of salt wells located near the reactor site are analyzed. Emergency core cooling system capabilities are described. (D.C.C.)

**16044** (DOCKET-50329-10) [MIDLAND PLANT, UNITS 1 AND 2]. [Preliminary Safety Analysis Report], Amendment 8. (Consumers Power Co., Jackson, Mich.). 10 Feb 1970. 112p. (DOCKET-50330-10). Dep. CFSTI.

Revised and additional information is given on the Midland Power Reactor, Units 1 and 2. Changes in cooling system design are described; data are tabulated. Details relating to the quality assurance programs are summarized. The Class I piping is considered with respect to USAS B31.1. Seismic loadings of Class I systems and structures are discussed. Control room protection is described; calculations illustrate adequacy of the shielding. Soils data, including boring logs for the Midland site, are presented. Responsibilities for structures, systems, and components are tabulated. (M.L.S.)

**16045** (DOCKET-50331-20) DUANE ARNOLD ENERGY CENTER. Preliminary Safety Analysis Report, Amendment 14. (Iowa Electric Light and Power Co., Cedar Rapids). 30 Jan 1970. 5p. Dep. CFSTI.

Additional information is presented concerning the effects of pipe rupture and pipe motion on containment structure integrity. Missile generation due to cooling system component or piping failure is analyzed. (D.C.C.)

**16046** (DOCKET-50331-21) DUANE ARNOLD ENERGY CENTER. Preliminary Safety Analysis Report, Amendment 15. (Iowa Electric Light and Power Co., Cedar Rapids). 5 Feb 1970. 4p. Dep. CFSTI.

Additional information is presented concerning the effects of pipe rupture and pipe motion on containment structure integrity. (D.C.C.)

**16047** (DOCKET-50331-22) DUANE ARNOLD ENERGY CENTER. Safety Evaluation. (Division of Reactor Licensing (AEC), Washington, D. C.). 13 Feb 1970. 110p. Dep. CFSTI.

For Iowa Electric Light and Power Co., Cedar Rapids.

The complete safety evaluation of the Duane Arnold Power Reactor by the AEC Division of Reactor Licensing is given. Summary considerations are included on the following topics: site, nuclear steam supply systems, containment, engineered safety features, structural design, instrumentation and control systems, electrical power systems, waste processing system, balance of plant, accident analysis, quality assurance, research and development programs, technical qualifications, conformance to general design criteria, ACRS report, common defense and security, and financial qualifications. (M.L.S.)

**16048** (DOCKET-50333-18) JAMES A. FITZPATRICK NUCLEAR POWER PLANT. Preliminary Safety Analysis Report, [Amendment 14]. (Power Authority of the State of New York). 30 Jan 1970. 2p. Dep. CFSTI.

Additional information is presented concerning pipe movement within the primary containment structures. (D.C.C.)

**16049** (DOCKET-50333-19) JAMES A. FITZPATRICK NUCLEAR POWER PLANT. [Preliminary Safety Analysis Report], Amendment 15. (Power Authority of the State of New York). 18 Feb 1970. 51p. Dep. CFSTI.

An updated list of trustees and principal officers is given for the Power Authority of the State of New York (PASNY), owners of the James A. FitzPatrick Power Reactor. The complete 1968 PASNY is included, along with interim 1969 financial data. (M.L.S.)

**16050** (DOCKET-50334-15) BEAVER VALLEY POWER STATION, UNIT NO. 1. Report on Shear Assembly Tests for Reactor Containment Wall. (Duquesne Light Co., Pittsburgh, Pa.). Dec 1969. 59p. Dep. CFSTI.

**16051** (DOCKET-50334-16) BEAVER VALLEY POWER STATION. [Preliminary Safety Analysis Report], Amendment 13. (Duquesne Light Co., Pittsburgh, Pa.). 30 Jan 1970. 322p. Dep. CFSTI.

Details relating to population, meteorology and probable maximum flooding at the Beaver Valley Power Reactor Site are discussed; soils data and boring logs are given. Reduction in feed water enthalpy is discussed; methods of preventing this removal of excess heat are described. Post-design-basis-accident hydrogen generation is discussed. Integrated thyroid and external radiation doses are tabulated for design basis accident conditions. The complete preliminary technical specifications are included. An overall description of the quality assurance program is given. The seismic design and damping values used for Class I systems and structures are shown. (M.L.S.)

**16052** (DOCKET-50334-17) BEAVER VALLEY POWER STATION, UNIT NO. 1. A Review of the Welding Procedures and Materials Used in Fabricating Shear Bar Assemblies. (Duquesne Light Co., Pittsburgh, Pa.). 26 Jan 1970. 6p. Dep. CFSTI.

**16053** (DOCKET-50334-18) BEAVER VALLEY POWER STATION, [UNIT NO. 1]. Preliminary Safety Analysis Report, Amendment 14. (Duquesne Light Co., Pittsburgh, Pa.). 20 Feb 1970. 127p. Dep. CFSTI.

Loading-combination equations for containment vessel liner design for the Beaver Valley Power Reactor are listed. The components for the river water supply system are described. Revised and additional pages to the PSAR are also included. (M.L.S.)

**16054** (DOCKET-50335-12) HUTCHINSON ISLAND PLANT, UNIT NO. 1. [Preliminary Safety Analysis Report], Amendment 7. (Florida Power and Light Co.). 6 Feb 1970. 20p. Dep. CFSTI.

Revised information related to seismic stresses on the reactor building and auxiliary buildings is presented. Seismic stresses on Class-1 piping systems are analyzed. (D.C.C.)

**16055** (DOCKET-50336-7) MILLSTONE NUCLEAR POWER STATION, UNIT 2. Preliminary Safety Analysis Report, Amendment 3. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). 6 Jan 1970. 140p. Dep. CFSTI.

Piping classifications are listed. The reactions of Zr to water and the release of $ZrO_2$ under coolant loss conditions are analyzed. Testing programs are described. Auxiliary systems for coolant loss conditions are analyzed. Containment ventilation systems are described. Radiation waste system is illustrated. Core and cooling system components support structures are described. Flow response for the emergency core cooling system is presented. The auxiliary power system is described. The personnel training program is outlined. (D.C.C.)

**16056** (DOCKET-50336-8) MILLSTONE NUCLEAR POWER STATION, UNIT 2. Preliminary Safety Analysis Report, Amendment 4. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). 5 Feb 1970. 82p. Dep. CFSTI.

Flood protection requirements are described. Design parameters for the core and cooling system components support structures are presented. Seismic stress limits for containment structures and piping systems are analyzed. Pipe rupture protection requirements are listed. Engineering drawings of the buildings and systems are included. (D.C.C.)

**16057** (DOCKET-50338-10) NORTH ANNA POWER STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Amendment 4, Supplement, Vol. 1. (Virginia Electric and Power Co., Richmond). 26 Jan 1970. 348p. (DOCKET-50339-10). Dep. CFSTI.

Personnel qualifications are presented. Testing programs are described. Environmental monitoring programs are outlined. Seismic stress analysis for the site is presented. Flood protection requirements are analyzed. Inspection programs are described. Failure testing requirements for primary cooling system components are presented. Manufacture and installation procedures for the pressure vessels are described. (D.C.C.)

**16058** (DOCKET-50338-11) NORTH ANNA POWER STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Amendment 4, Supplement, Vol. 2. (Virginia Electric and Power Co., Richmond). 26 Jan 1970. 312p. (DOCKET-50339-11). Dep. CFSTI.

Stress analyses of Class 1 containment structures and component support structures are presented. Operation of engineered

safeguard systems is described. Safety system instrumentation circuits are presented. Auxiliary power system operation is described. Auxiliary feed pump circuits for the power conversion system are presented. Waste disposal systems are described. Radionuclide discharge rates to the environment under accident conditions are listed. Personnel training requirements are described. Pressure, temperature, and water flow transients under accident conditions are analyzed. (D.C.C.)

**16059** (DOCKET-50338-13) [NORTH ANNA POWER STATION, UNITS 1 AND 2]. [Preliminary Safety Analysis Report, Amendment 4, Vol. 3]. (Virginia Electric and Power Co., Richmond). [1970]. 95p. (DOCKET-50339-13). Dep. CFSTI.

Revised physics measurements are presented. Fuel element design parameters are described. The containment ventilation system is also described. Auxiliary ventillation system operation is discussed. Management personnel structure of VEPCO is listed. Containment structure design requirements are presented. (D.C.C.)

**16060** (DOCKET-50338-14) NORTH ANNA POWER STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Amendment 5. (Virginia Electric and Power Co., Richmond). 6 Feb 1970. 80p. (DOCKET-50339-14). Dep. CFSTI.

Revised information is presented concerning design parameters of containment structures. Engineered safeguards are described. Actuation sequence of emergency systems during design basis accident is presented. Maximum containment pressures during seasons of the year are described. (D.C.C.)

**16061** (DOCKET-50352-1) LIMERICK GENERATING STATION, UNITS NO. 1 AND 2. License Application. (Philadelphia Electric Co., Pa.). 26 Feb 1970. 43p. (DOCKET-50353-1). Dep. CFSTI.

**16062** (DOCKET-50352-2) LIMERICK GENERATING STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Vol. 1. (Philadelphia Electric Co., Pa.). 27 Feb 1970. 425p. (DOCKET-50353-2). Dep. CFSTI.

Detailed site data on the Limerick Power Reactor, Units 1 and 2 are given. The meteorology, hydrology, geology and seismology, and soils characteristics are described. The environmental monitoring program is detailed. (M.L.S.)

**16063** (DOCKET-50352-3) LIMERICK GENERATING STATION, UNITS NO. 1 AND 2. Preliminary Safety Analysis Report, Vol. 2. (Philadelphia Electric Co., Pa.). 27 Feb 1970. 467p. (DOCKET-50353-3). Dep. CFSTI.

Information on the Limerick Power Reactor, Units 1 and 2, is given on the following broad topics: Reactor; Reactor Coolant System; Containment; and Core Standby Cooling System. (M.L.S.)

**16064** (DOCKET-50352-4) LIMERICK GENERATING STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Vol. 3. (Philadelphia Electric Co., Pa.). 27 Feb 1970. 397p. (DOCKET-50353-4). Dep. CFSTI.

Details of the control system and instruments for the Limerick Power Reactor, Units 1 and 2, are given. Line diagrams and schematics are included. (M.L.S.)

**16065** (DOCKET-50352-5) LIMERICK GENERATING STATION, UNITS NO. 1 AND 2. Preliminary Safety Analysis Report, Vol. 4. (Philadelphia Electric Co., Pa.). 27 Feb 1970. 360p. (DOCKET-50353-5). Dep. CFSTI.

Information on the Limerick Power Reactor, Units 1 and 2, is given on the following broad topics: Electrical Power Systems; Radioactive Waste Systems; Auxiliary Systems; Power Conversion Systems; Plant Structures and Shielding; Conduct of Operations; and Plant Safety Analysis. (M.L.S.)

**16066** (DOCKET-50352-6) LIMERICK GENERATING STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Vol. 5. (Philadelphia Electric Co., Pa.). 27 Feb 1970. 219p. (DOCKET-50353-6). Dep. CFSTI.

Classifications and codes for design of the piping and equipment for the Limerick Power Reactor, Units 1 and 2, are tabulated. Seismic design and materials for the systems and equipment are discussed. A complete set of proposed technical specifications are included. Structural design criteria are tabulated. The proposed quality assurance program is outlined. Site assembly of the reactor pressure vessels is discussed. (M.L.S.)

**16067** (DOCKET-50354-1) NEWBOLD ISLAND NUCLEAR GENERATING STATION, [UNITS 1 AND 2]. Preliminary Safety Analysis Report, Vol. 1. (Public Service Electric and Gas Co., Newark, N. J.). 27 Feb 1970. 610p. (DOCKET-50355-1). Dep. CFSTI.

Information on the site and environs of the Newbold Power Reactor, Units 1 and 2, is presented. The appendices contain complete reports from consultants on: meteorology, earth sciences, soils liquefaction studies, maximum and minimum water levels, and water usage. (M.L.S.)

**16068** (DOCKET-50354-2) NEWBOLD ISLAND NUCLEAR GENERATING STATION, [UNITS 1 AND 2]. Preliminary Safety Analysis Report, Vol. 2. (Public Service Electric and Gas Co., Newark, N. J.). 27 Feb 1970. 527p. (DOCKET-50355-2). Dep. CFSTI.

Information on Newbold Island Power Reactor, Units 1 and 2 is given under the following broad topics: Reactor; Reactor Cooling System; Containment; and Core Standby Cooling System. (M.L.S.)

**16069** (DOCKET-50354-3) NEWBOLD ISLAND NUCLEAR GENERATING STATION, [UNITS 1 AND 2]. Preliminary Safety Analysis Report, Vol. 3. (Public Service Electric and Gas Co., Newark, N. J.). 27 Feb 1970. 437p. (DOCKET-50355-3). Dep. CFSTI.

Information on the preliminary design of the control and instrumentation systems and electrical power systems for the Newbold Island Power Reactor, Units 1 and 2 is detailed. Schematics, circuit diagrams, and engineering drawings are included. (M.L.S.)

**16070** (DOCKET-50354-4) NEWBOLD ISLAND NUCLEAR GENERATING STATION, [UNITS 1 AND 2]. Preliminary Safety Analysis Report, Vol. 4. (Public Service Electric and Gas Co., Newark, N. J.). 27 Feb 1970. 318p. (DOCKET-50355-4). Dep. CFSTI.

Information on the Newbold Power Reactor, Units 1 and 2, is given on the following broad topics: Radioactive Waste Systems; Auxiliary Systems; Steam and Power Conversion System; Structures and Shielding; Conduct of Operations; and Safety Analysis. (M.L.S.)

**16071** (DOCKET-50354-5) NEWBOLD ISLAND NUCLEAR GENERATING STATION, [UNITS 1 AND 2]. Preliminary Safety Analysis Report, Vol. 5. (Public Service Electric and Gas Co., Newark, N. J.). 27 Feb 1970. 172p. (DOCKET-50355-5). Dep. CFSTI.

Station design criteria are detailed for the Newbold Island Power Reactor, Units 1 and 2. The quality assurance program is described; owner and vendor programs are defined; in-service inspection plans are discussed. (M.L.S.)

**16072** (DOCKET-50354-6) NEWBOLD ISLAND NUCLEAR GENERATING STATION, [UNITS 1 AND 2]. APPLICATION FOR LICENSES. (Public Service Electric and Gas Co., Newark, N. J.). 27 Feb 1970. 47p. (DOCKET-50355-6). Dep. CFSTI.

**16073** (EUR-4391) OBRIGHEIM NUCLEAR POWER PLANT. Annual Report, 1968. (Kernkraftwerk Obrigheim G.m.b.H., Stuttgart (West Germany)). 29 Sep 1969. 108p. (In German). Dep. CFSTI (U. S. Sales Only).

The progress of work at the Obrigheim Nuclear Power Plant is reported. After the solution of the problems with the thermal shield and the successful completion of the start-up work, the reactor was charged with 121 fuel elements on 5–6 September 1968. Following this first criticality a program of measurements was carried out at zero power (≤1 MW) in order to check the design nuclear physics calculations on the newly charged reactor. The plant was then gradually run up. After rectification of a few minor snags the turboset was synchronized with the grid for the first time on 29 October 1968. Then, in November 1968, trials were carried out at 20, 30 and 50% reactor power. At power levels above 50% the moisture separators in the steam generators could not achieve the required terminal moisture content of 0.25%. The resultant modifications carried out did not have the required effect. Satisfactory results were not achieved until new steam driers were installed (27 January–3 February 1969). Information on staffing, power and water consumption on the site, plant operation, fuel economy, and the progress of the acceptance procedure is presented. Economic data are also included. (auth)

**16074** (EUR-4394) 50-MWe DODEWAARD NUCLEAR POWER PLANT. Annual Report, 1968. (Gemeenschappelijke Kernenergiecentrale Nederland N. V., Dodewaard. Samenwerkende Electriciteits-Productiebedrijven, N. V., Arnhem (Netherlands)). 30 Sep 1969. 68p. (In Dutch). Dep. CFSTI (U. S. Sales Only).

The year 1968 began with the arrival on 4 January of the reactor pressure vessel, and ended with the completion on 29 December of the SEP serviceability test. As early as 6 March, while the work on and around the pressure vessel was still in full swing at Dodewaard, the first core criticality was reached in a critical assembly

at Petten. On 2 April, the first fuel elements were delivered to the site. The zero-power testing phase commenced on 24 June, when for the first time criticality was reached in the reactor vessel. On 4 September it was possible to begin the test phase nuclear run-up to rated temperature and pressure, and this was followed on 7 October by the start of test phase synchronization of the generator with the grid. In the intervals between the various test phases the respective results were assessed by the Reactor Safety Groups. On 25 October the power plant, operating at a power of 10 MW(e), fed electricity into the 250 kV national grid for the first time. The reactor was then brought up to full thermal power via the 33%, 50% and 75% levels, and on 14 December it was possible to begin the above-mentioned SEP test. (auth)

**16075** (GA-9678) THE FORT ST. VRAIN PRESTRESSED CONCRETE REACTOR VESSEL: PROGRESS OF CONSTRUCTION. Peinado, C. O.; Plaehn, J. L.; Way, W. J. (Gulf General Atomic, Inc., San Diego, Calif.). 15 Sep 1969. Contract AT(04-3)-633. 44p. (CONF-691030-1). Dep. CFSTI.

From American Society Civil Engineer Convention, Chicago, Ill.

The status of the Fort St. Vrain PCRV is described. The PCRV design, inspection and quality assurance responsibilities, construction materials properties, and construction methods are emphasized. 3 references. (H.D.R.)

**16076** (LIB/Trans-192) SMALL AND MEDIUM POWER OUTPUT REACTORS FOR THE REMOTE REGIONS OF THE U.S.S.R. Sergeev, Yu. A. Translated by Jack Kristo (AAEC, Research Establishment, Lucas Heights), from Conference on Small and Medium Power Output Reactors, Vienna, June 24-28, 1968. 25p. Dep. CFSTI (U. S. Sales Only).

The economics of small reactors for use in remote areas of the USSR is reviewed. Various types of reactors are discussed, and the design and performance of a 12MW(t) pressurized-water reactor is outlined. This reactor uses natural convection to circulate the primary coolant. It is claimed that installations such as this could be competitive in remote regions. Descriptions of three reactors in operation (TES-3; ARBUS; VK-50) and one under construction (BILIBINSK-NPP), are given. (auth)

**16077** (TID-25323) SENA NUCLEAR POWER PLANT. Annual Report, 1968. (Societe d'Energie Nucleaire Franco-Belge des Ardennes, Chooz-lez-Givet (France)). 32p. Dep. CFSTI.

**16078** (TID-25324) GARIGLIANO NUCLEAR POWER STATION. Operation Report for the 3rd Quarter of 1969. (Ente Nazionale per l'Energia Elettrica, Rome (Italy)). 30 Sep 1969. 15p. Dep. CFSTI.

The Garigliano plant operating statistics for the period July through September 1969 are summarized. Control rod patterns during the quarter and radial power and fuel element burnup distributions at the end of the period are presented. Data obtained from plant chemistry and health physics measurements are tabulated. (H.D.R.)

**16079** (TID-25329) GUNDREMMINGEN NUCLEAR POWER PLANT. Monthly Report, November 1969. (Kernkraftwerk RWE-Bayernwerk G.m.b.H., Gundremmingen (West Germany)). 22 Dec 1969. 40p. (In German). Dep. CFSTI.

The installation was run at full power for the whole of the period covered. The exhaust-gas activity was between 30 and 45 mCi/sec. As a result of careful preparations the inspection and repair of the fuel elements removed from the reactor in the summer were conducted without affecting operation. By the end of November 52 elements had been inspected and 83 defective fuel rods removed. (auth)

**16080** (TID-25330) GARIGLIANO NUCLEAR POWER PLANT. Annual Report, 1968. (Ente Nazionale per l'Energia Elettrica, Rome (Italy)). 19 Sep 1969. 112p. Dep. CFSTI.

The working period 1 March 1968-28 February 1969 is summarized. During that period the Garigliano plant operated with an average utilization factor of 73.3% and generated a total electricity output of 1,028 million kWh. On 30 July 1968, the close of the 1-C cycle, the plant was shut down and stayed out of service until 10 October 1968, the start of cycle 2, for general servicing and modifications to certain plant components and for refuelling of the reactor with 54 fresh and 18 part-irradiated U elements, together with twelve prototype Pu elements comprising 8 of standard and 4 of advanced type. On 28 February 1969 the average core burnup was 7,900 MWd/t of U while the maximum element burnup had reached 14,600 MWd/t. During cycle 1-C there were 13 shut-downs, with a total outage of 757 hours. Leakages in the feed water preheaters caused 6 shut-downs totalling 576 hours; 3 shut-downs, for 134 hours, were caused by the turboset and the main transformer; and lastly, 2 shut-downs, for 28 hours, were required to stop leaks in the turbine bleed and drain lines. There were also two spurious reactor scrams due to the reactor HP pressure switches (9 hours) and a grid disturbance (9 hours). The core power efficiency at the end of cycle 1-C was 11,000 MWd/t. The replacement of the Cu alloy preheaters by stainless steel units during the scheduled shutdown substantially altered the chemistry of the primary circuit. The levels of products in suspension fell to extremely low values (practically zero for Cu and Ni). As to the corrosion products in suspension, the Cu values remained virtually unchanged, but Ni and Fe dropped to extremely low concentrations. (auth)

**16081** (TID-25354) GUNDREMMINGEN NUCLEAR POWER STATION MONTHLY REPORT, DECEMBER 1969. (Kernkraftwerk RWE-Bayernwerk G.m.b.H., Gundremmingen (West Germany)). 1 Jan 1970. 43p. (In German). Dep. CFSTI.

**16082** (WAPD-MRP-128) PRESSURIZED WATER REACTOR PROJECT. Technical Progress Report, January 25, 1969-April 25, 1969. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Contract AT-11-1-GEN-14. 30p. Dep. CFSTI.

Power operation of Shippingport PWR Core 2 with Seed 1 installed was terminated on March 1, 1969 after 13,652 EFPH of operation; this is about 37% more than the design life of 10,000 EFPH. A test program for use during beginning of PWR-2 Seed 2 operations following the first 150 MW (e) demonstration was submitted to the AEC. The PWR-2 Seed 1-Seed 2 refueling was started. Approval of the radioactive waste disposal program to be used during the refueling period was received. In the process of performing criticality hazards evaluations of potential accident configurations which might be possible during PWR Core 2 Seed 1-Seed 2 refueling it was determined that the reflective properties of lead shielding can add significantly to the reactivity level of fuel assemblies. (auth)

**16083** (WAPD-MRP-129) PRESSURIZED WATER REACTOR (PWR) PROJECT. Technical Progress Report, April 26, 1969-July 25, 1969. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Contract AT-11-1-GEN-14. 26p. Dep. CFSTI.

Shippingport PWR-2 Seed 1-Seed 2 refueling was completed on May 29, 1969. Core 2 Seed 2 initial criticality was achieved on June 16, 1969. PWR-2 Seed 2 power operations began July 6, 1969. The 1B Main Coolant Pump which failed in service during Seed 1 life was successfully repaired and placed back in operation during the refueling shutdown. Several nuclear instrument "noise" interference problems were encountered during the refueling shutdown and were successfully resolved. The PWR-2 Seed 2 Nuclear Protection Analysis was completed. (auth)

**16084** ORIENTING STUDIES ON THE RADIOLYSIS PROCESSES IN THE PRIMARY CIRCUIT OF THE RHEINSBERG WATER-WATER POWER REACTOR WWER. Proesch, U.; Winkler, R. (Institut fuer Angewandte Isotopenforschung, Berlin. VEB Kernkraftwerk, Rheinsberg, Ger.). Kernenergie; 12: 352-7(Nov 1969). (In German).

The radiolysis products $N_2$, $H_2$, $O_2$, $NH_3$ in the primary coolant circuit of the Rheinsberg Power Reactor have been studied under typical conditions of operation. The supply water added had, in the mean, a content of $0.9 \times 10^{-6}$ mol/l $O_2$, the ammonia concentration was varied from $0.1 \times 10^{-3}$ up to $5 \times 10^{-3}$ mol/l. Steady-state values of the radiolysis products were established for a given ammonia concentration. In the range up to $3 \times 10^{-3}$ mol/l ammonia, a simple radiolysis of ammonia is observed in the primary coolant circuit. The oxygen content of the circulating water decreases but a little with increasing concentration of ammonia and is below $2 \times 10^{-6}$ mol/l. The results are discussed with respect to the mechanism of water radiolysis. 9 references. (auth)

**16085** THE ESTIMATION OF FUEL ELEMENT FAILURES FROM FISSION PRODUCT ACTIVITY MEASUREMENTS IN THE PRIMARY COOLANT OF THE RHEINSBERG NUCLEAR POWER PLANT. Langecker, K.; Winkler, R. (VEB Kernkraftwerk, Rheinsberg, Ger.). Kernenergie; 12: 357-62(Nov 1969). (In German).

Processes are discussed that may cause transition of fission products from the fuel elements into the coolant. On the basis of model concepts the fission product activities measured since start of the nuclear power plant are discussed. The methods for calculating the characteristic quantities are given, from which conclusions can be made for the degree of fuel element leakages. 5 references. (auth)

**16086** DECONTAMINATION OF THE RHEINSBERG NUCLEAR POWER PLANT PRIMARY COOLANT CIRCUIT. Winkler, R.; Legler, D.; Schultes, K. W.; Langecker, K. (VEB Kernkraftwerk, Rheinsberg, Ger.). Kernenergie; 12: 341-7(Nov 1969). (In German.)

The three-stage decontamination technique developed for the Rheinsberg Power Reactor differs from similar methods by its low demand for chemical agents. Corrosion of the materials exposed to the decontaminating solutions as well as problems of waste water treatment were studied. The first decontamination of a loop of the primary coolant circuit took place after operation of 430 effective days. Decontamination factors up to 25 have been obtained. Deleterious secondary effects did not occur. 11 references. (auth)

**16087** INFORMATION THEORY APPLIED TO THE MANAGEMENT OF THE FUEL CYCLE OF A GENERATING STATION. Bressange, Jean; Euzet, Jacques. Ind. At., 13: No. 9-10, 35-43(1969). (In French).

The problem of fuel cycle management in graphite-gas reactors is outlined; Chinon-2 is used as a specific example. The overall methods used for calculations of fuel burnup and the parameters used in these calculations are discussed. A flow diagram for the CDC-6600 computer program which is used for the management decisions is shown. Industrial applications of both the computerized fuel management concept and the graphite-gas reactor are considered. (M.L.S.)

**16088** PALISADES PWR NUCLEAR POWER STATION. Nucl. Eng. Int.; 15: 27-42(Jan 1970).

A series of articles describes the 710 MW(e) Palisades PWR plant on Lake Michigan, which is the first to be built on a non-turnkey basis. Details are given of environmental studies for thermal effects, sitework and plant construction. There are descriptions of the reactor core including fuel elements, control rods, coolant, safety systems and emergency cooling system. Fuel handling and storage facilities are considered; the radioactive waste treatment plant is described. Instrumentation and control systems are discussed. A large colored sectional diagram of the reactor, with a full list of parameters, is presented. (UK)

**16089** FOLLOWING OF THE REACTIVITY IN POWER REACTORS: ANALYSIS OF THE BEHAVIOR OF POWER REACTORS THROUGH IN-CORE INSTRUMENTATION. Caro, R. Energ. Nucl. (Madrid), 13: 47-54(Jan.-Feb. 1969). (In Spanish).

The general considerations in building a power reactor are outlined. Requirements for in-core instrumentation are discussed; the in-core instrumentation in the Zorita Power Reactor is described briefly. Methods for processing of data from the instrumentation are outlined. 25 references. (M.L.S.)

**16090** INFLUENCE OF TECHNICAL-ECONOMIC PARAMETERS ON THE COMPARISON OF NUCLEAR ENERGY PRODUCTION COSTS. Belelli, U.; Gualtieri, G.; Sani, L. (Ente Nazionale per l'Energia Elettrica, Rome). pp 41-52 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

A comparison of the costs of the power produced by different types of reactor illustrates the problems underlying the hypotheses assumed for the rate of interest, the economic life of the facility, and its utilization factor. The problems relating to the intrinsic capacity of each type of reactor for exploiting, within a certain limit, the power potential of the source material, together with the economic significance of this, are dealt with in detail. The experience of ENEL in operating the three power stations at Garigliano, Latina and Trino Vercellese, these being boiling-water, pressurized water, and gas-graphite reactors respectively is used to illustrate the problems. 9 references. (auth)

**16091** A STATISTICAL ANALYSIS OF THE CONSTRUCTION COSTS OF NUCLEAR POWER PLANT. Martensson, M. (Aktiebolaget Atomenergi, Stockholm). pp 125-38 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Up to the end of March 1967 some 80 light-water reactors had been built, were under construction or firmly planned in the whole world. About three quarters of these nuclear plants were built or ordered for construction in the United States of America. The construction costs of the separate plants have been published with varying degrees of accuracy and completeness of detail. Furthermore, the different reactors are distributed in a wide range of size and were built—or ordered—at different points of time. To determine some empirical laws for description of this historical reality—or, anyhow, to reach some conclusions of general nature—the cost data were treated by means of regression analysis using the method of least squares. The basis of this analysis is a simple equation expressing the unit cost of construction as a function of the reactor size and the date of initial operation, and its purpose is to determine the nature and extent of the relationship between these variables. A simple model for taking into account the effect of rising costs of labor and material is presented. The method is illustrated in the first place by using a number of light-water reactors that are built or ordered in the United States but a few tentative comparisons with European reactors are also made. 7 references. (auth)

**16092** CANADIAN EXPERIENCE IN THE INTERNATIONAL NUCLEAR POWER MARKET. Fortune, R. F. (Canadian General Electric, Peterborough, Ont.). pp 155-71 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

The results of an international study in Canada identified as the Venture study are described. Plant cost estimates, fueling cost estimates and operating cost estimates for 133-, 350- and 600 MW(e) heavy water reactor plants are given. Qualitative assumptions concerning the cost of construction of heavy water reactor plants in industrialized and non-industrialized countries are given. (auth)

**16093** INTERNATIONAL EXTRAPOLATION AND COMPARISON OF NUCLEAR POWER COSTS OF PLANTS WITH BOILING WATER REACTORS. Schwarz, D. J. (Allgemeine Elektrizitaets-Gesellschaft, Frankfurt am Main). pp 173-84 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

The calculations of nuclear power costs in Germany are discussed. Essential aspects of extrapolation of these costs to other countries is considered for the case of a boiling water reactor. (auth)

**16094** PROBLEMS INVOLVED IN COST EVALUATION OF NUCLEAR POWER STATIONS IN JAPAN. Inouye, T.; Tuzuki, T.; Watase, H. (Ministry of International Trade and Industry, Tokyo). pp 185-92 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

The present stage of commercial nuclear power development in Japan is represented by four nuclear stations: Tokai nuclear power station of the Japan Atomic Power Company now in operation, and three other projects under construction. There is therefore as yet no firm information on nuclear power production costs. The Tokai station is the first commercial-sized plant to be operated in Japan and a great deal of research and development was connected with it. Consequently it is impossible to derive a fair economic value. The three stations now under construction are estimated to have a power production cost of Y.3.00/kWh for the initial year and Y.2.50/kWh average production cost for the station lifetime. Nuclear power stations are expected to be competitive with fossil-fuel stations in the near future because of cost reductions from technical innovations and the adoption of large unit sizes. All the four stations mentioned above have been imported from either the United Kingdom or the United States of America, but the power production costs will reflect the various special conditions that predominate in Japan. These include the current interest rate, depreciation methods, siting restrictions, and load factor. In the economic evaluation of nuclear power stations in Japan there are many problems that require profound study. These include possible reductions in construction costs, technical innovations, the price trend of fissionable fuel, spent fuel reprocessing costs, plutonium prices, and others. The present status and future outlook of nuclear power station costs in Japan, and the present problems involved in evaluation, are discussed. Present conditions peculiar to making cost estimates in Japan are also described. Finally, an approach to solving various problems involved in making cost calculations is presented. (auth)

**16095** THEORETICAL ANALYSIS OF THE PHYSICS CHARACTERISTICS OF THE TARAPUR CORE UNDER VARIOUS CONDITIONS. Balakrishnan, M. R. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 386-9(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

**16096** THE PHYSICS FEASIBILITY OF RECYCLING THE PLUTONIUM FROM RAJASTHAN REACTORS IN THE TARAPUR CORE. Bhatia, H. K.; Balakrishnan, M. R. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 392-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Two sets of calculations are presented which indicate the amounts of Pu required in each recycle to achieve an average fuel burnup of 10000 MWD/T and 15000 MWD/T. The reactor core is represented by a unit cell with a constant buckling to take into account the neutron leakage. 6 references. (D.C.C.)

**16097** STABILITY OF LARGE NUCLEAR REACTORS. Purandare, H. D. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 396-9(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Stability of CANDU-type reactors is studied with respect to xenon oscillations. Three reactors are considered: RAPP Power Reactor; Pickering Power Reactor Unit 1; and a representative reactor of 280 MW(e). 3 references. (D.C.C.)

**16098** UTILITY SYSTEMS OF THE FUTURE. Ritchings, Frank A. (Ebasco Services, Inc., New York). Combustion; 41: No. 3, 32-5(Sep 1969).

The goals of the United States electric utility systems for the year 2000 are examined. The physical characteristics of the systems are envisioned, and the quality of advanced planning needed to attain the goals is discussed. Electric utility production plant construction requirements and programs to increase transmission and distribution capacity are examined. (H.D.R.)

**16099** ANATOMY OF A NUCLEAR STEAM ISOLATION VALVE. Bradshaw, C. L. W. Combustion; 41: No. 5, 29-32 (Nov 1969).

The production of a steam isolation valve is examined from design to inspection and testing. The valve described is specifically for service on the reactor-to-turbine steam lines of boiling water reactor power plants. (H.D.R.)

**16100** RELIABILITY OF REACTOR SAFETY SYSTEMS. Schultz, M. A. (Pennsylvania State Univ., University Park). Power Eng.; 74: 46-9(Jan 1970).

The reliability of safety circuits for nuclear reactor systems is discussed. Failure rates for safety system components are defined, and the costs for added circuitry to increase reliability are examined. The potential of using a computer to constantly test electronic safety system components to allow immediate repair of faults is discussed. (H.D.R.)

**16101** AD HOC COMMITTEE ON PRACTICAL VALUE [OF POWER REACTORS]. New York; Atomic Industrial Forum, Inc. (1969). 19p.

The practical value concept with respect to power reactors is defined, and the present law on power reactor licensing is compared with pending legislation. The significance of a practical value finding under present law is examined. Areas of the present law and proposed legislation on practical value that need clarification are discussed. (H.D.R.)

**16102** BWR REQUIRES AUTOMATED AIR EJECTORS AND PRECAUTIONS AGAINST RADIOACTIVE EMISSIONS. Power; 114: No. 2, 38-9(Feb 1970).

Steam-jet air ejectors (SJAE) are used to maintain adequate vacuum in the condenser of a steam turbine. In a boiling water reactor plant, the ejectors must remove air plus noncondensible gases formed from dissociation of steam. These gases must be held up to allow for radioactive decay and then filtered to remove particulate matter before stack discharge. The design features and degree of automation of SJAE systems for BWR plants are discussed. (H.D.R.)

**16103** NO. 3 PLANT IN THE FUKUSHIMA ATOMIC POWER STATION OF TOKYO ELECTRIC POWER COMPANY. Toyota, Masatoshi (Tokyo Electric Power Co.). Ohm (Elec. Mag.); 56: No. 13, 17-23(Nov 1969). (In Japanese).

Plans for the No. 3 plant in the Fukushima Atomic Power Station are under safety inspection by the Government; the construction is scheduled for January 1970, and the plant operation for December 1974. Similar to No. 2 plant, it is a BWR with electric output of 784 MW; total charge of 107 tons of 2.5% enriched uranium, and fuel burnup of 27,500 MWd/t. The outstanding feature, which is quite different from the cases of No. 1 and 2 plants, is construction of No. 3 plant by Japanese industry; while both No. 1 and No. 2 plants were made by General Electric of the United States. The following are described: the domestic construction of the plant; the arrangement of the plant; the reactor and its auxiliaries; safety design, including anti-quake design; a turbogenerator; power distribution; instrumentation and control; and waste disposal. (NSA of Japan)

**16104** NO. 1 PLANT IN THE SHIMANE ATOMIC POWER STATION OF CHUGOKU ELECTRIC POWER COMPANY. Baba, Toshio (Chugoku Electric Power Co., Hiroshima). Ohm (Elec. Mag.); 56: No. 13, 32-9(Nov 1969). (In Japanese).

Chugoku Electric Power Company selected Kashima, Shimane Prefecture, as the site of the Shimane Atomic Power Station. The planning of construction, the investigation of specifications, and also the works at the site including survey, compensation, and site preparation is in progress. The company recently submitted a request to the Government for permission to install the atomic power station. The plant is expected to go into operation in June 1974. The site is situated at the middle of Shimane Peninsula and has a total area of 1,700,000 $m^2$. The atomic power station employs a BWR of 460 MW(e), fueled with Zircaloy-2 clad $UO_2$; the turbine is of the tandem, four-flow exhaust and nonreheating type, and the generator is of the water-cooled stator type. The following are described: the course leading to materialization of the plant; various investigations at the site, including geology, meteorology, etc.; site preparations; and the facilities of the power station, including reactor plant, turbine, generator, and instrumentation. (NSA of Japan)

**16105** NO. 1 PLANT IN THE TAKAHAMA ATOMIC POWER STATION OF KANSAI ELECTRIC POWER COMPANY. Ogawa, Takeshi (Kansai Electric Power Co., Osaka). Ohm (Elec. Mag.); 56: No. 13, 24-31(Nov 1969). (In Japanese).

Kansai Electric Power Company selected Takahama, Fukui Prefecture, at the site of the Takahama Atomic Power Station, following on No. 1 and 2 plants in the Mihama Atomic Power Station. The plan is under safety inspection by the Government, following a May 1969 request for a construction permit. The power station will go into operation in August 1974. Similar to its predecessor plants, the plant is a PWR by Westinghouse of the United States with electric output of 826 MW. Although differing somewhat from the plants in the Mihama Station in reactor core, fuel, etc., its safety design is essentially the same as the Mihama plants. The following are described: the outline of construction plan; the site, and the survey about geology, meteorology, earthquakes, etc.; and the facilities, including the reactor, cooling system, a turbogenerator, a reactor housing, instrumentation, etc. (NSA of Japan)

**16106** TIHANGE NUCLEAR POWER STATION. Energ. Nucl. (Paris); 11: 557-60(Dec 1969). (In French).

The Franco-Belgian power station now being built at Tihange, in Belgium, is described. The reactor, of the light water type under pressure will have a thermal power of 2,660 MW(t), corresponding to an electrical power of 870 MW(e). Three cooling loops each contain two separate heat exchange circuits. The fuel used is slightly enriched (2.06 to 3.22%) $UO_2$ oxide. The station is expected to come into industrial operation on 30th November 1974. (auth)

**16107** CAPACITY EXPANSION OPTIMIZATION IN A GROWING NUCLEAR FUEL FABRICATION INDUSTRY. Homan, F. J.; Washburn, T. N. (Oak Ridge National Lab., Tenn.). Nucl. Appl. Technol.; 8: 384-94(Apr. 1970).

Optimized schedules for the expansion of fabrication capacity for nuclear fuels can result in substantial savings to the electrical economy. This is evident when the fabrication costs for optimized schedules are compared with conservative schedules based only on near-term demand. A method is presented by which such optimization is achieved through mathematical simulation of numerous logically selected expansion schedules which are all based on the same time-dependent demand data. The schedules are generated by assuming different plant utilization policies and planning horizons, and are compared on a levelized unit cost basis. The schedule yielding the lowest cost over the time period studied is defined as optimum. A parametric analysis is included to show the variation of optimum expansion schedules and unit costs with changes in the various economic parameters. (auth)

**16108** NUCLEAR REACTORS: 1969 INITIAL CRITICALITY. Atomwirt., Atomtech.; 14: 584(Dec 1969). (In German).

**16109** STARTUP OF THERMAL POWER STATIONS OVER 100 MW IN THE FEDERAL REPUBLIC 1968-1972. Atomwirt., Atomtech.; 14: 586(Dec 1969). (In German).

**16110** INDUSTRIAL SABOTAGE IN NUCLEAR POWER PLANTS. Turner, S. E.; McCullough, C. R.; Lyerly, R. L. Nucl. Safety; 11: 107-14(Mar-Apr 1970).

The consequences of industrial sabotage in nuclear power plants have been studied from the standpoint of the potential hazard to the health and safety of the public. This evaluation of the potential threat of sabotage considered (1) historical precedents, (2) the opinions of experienced and knowledgeable individuals, (3) motivation and likely extent of knowledge of various types of saboteurs, and (4) an assessment of the probability and possible consequences of a number of postulated sabotage acts, as well as the level of damage necessary to create a public hazard. On the basis of the study, it is concluded that, although sabotage with serious consequences to the public is possible in theory, the probability is sufficiently low that no undue risk to the health and safety of the public exists. 33 references. (auth)

**16111** CONSTRUCTION OF A SITE-ASSEMBLED NUCLEAR REACTOR PRESSURE VESSEL. Reedy, Roger F.; Sims, James E. Nucl. Safety; 11: 119-29(Mar-Apr 1970).

The Monticello Nuclear Generating Plant in Minnesota, owned by Northern States Power Company, is unique in that it has the first field-fabricated nuclear reactor pressure vessel built in the United States. The materials for this vessel were fabricated in the normal manner and shipped to the site for final assembly into a completed vessel. Special training for field machining, welding, and quality control was required. The completion of the pressure vessel ahead of schedule showed that the field fabrication of nuclear pressure vessels is both feasible and economical. (auth)

**16112** SAN ONOFRE EXPERIENCE WITH APPARENT POWER MISMATCH AND REACTOR COOLANT-TEMPERATURE ANOMALIES. Ortega, Orlando J.; Johnson, Carl G.; Baskin, Kenneth P. Nucl. Safety; 11: 142-50(Mar-Apr 1970).

In January 1968 the upper limit for operation at the San Onofre Nuclear Generating Station was set at 90% power, 405 MW(e), because discrepancies had been noted in reactor thermal power as reckoned by different methods. Calculations based on the temperature differentials across the steam generator in the primary loops gave one value, and calorimetrics in the secondary system gave another. It appeared that coolant flow was less than the design value. Extensive testing during March, September, and October 1968 revealed that temperature sensors gave misleading indications because of their locations. Accordingly, additional direct-immersion resistance temperature detectors (RTD's) were installed downstream of each coolant pump to give accurate cold-leg mixed-mean temperatures. Accurate core outlet temperatures were already being provided by core thermocouples. The data from the new RTD's proved that coolant flow actually was equal to or greater than design flow. On the strength of this knowledge, operation at 100% power rating, 450 MW(e), was begun in December 1968 after an 18-month investigation of the anomaly. The problem demonstrated the great need for instrumentation to accurately read two performance parameters in large PWR's: (1) mixed-mean hot- and cold-leg temperatures and (2) flow of primary coolant. (auth)

**16113** SAFETY-RELATED OCCURRENCES REPORTED IN OCTOBER–NOVEMBER 1969. Casto, W. R. (comp). Nucl. Safety; 11: 150-4(Mar-Apr 1970).

Nine occurrences relating to the safety of reactor operations and one related to the operation of x-ray equipment are reported. 10 references. (H.D.R.)

**16114** ACTION ON REACTOR AND OTHER PROJECTS UNDERGOING REGULATORY REVIEW OR CONSIDERATION. Blakely, J. P. (comp). Nucl. Safety; 11: 171-9(Mar-Apr 1970).

Regulatory and other actions relating to reactor projects as of December 1, 1969, are summarized. In-process license-application records of various power reactors are tabulated, and data are presented on reactors for which operating licenses have been issued. 11 references. (H.D.R.)

**16115** THERMAL DISCHARGES FROM LARGE NUCLEAR PLANT. Moyer, Stanley (Philadelphia Electric Co.); Raney, Edward C. J. Sanit. Eng. Div., Amer. Soc. Civil Eng.; 95: 1131-63(Dec 1969).

Problems encountered as a result of thermal effects on the Susquehanna River by the Peach Bottom nuclear power plant are discussed. The cooling water requirements of this plant are 3350 cfs. Periods of low river flow, high natural river water temperatures, and high wet bulb temperatures are considered the most critical times for aquatic organisms. Hydraulic model tests resulted in development of an efficient jet injection system which gives maximum rapid mixing effect. A jet of from 5 to 8 fps at the end of a long canal introduces the effluent throughout the entire depth of the water column in the reservoir. This system was superior to the use of a short discharge canal which utilized a weir to release the warm water at the surface at low velocity. The studies of isotherms as related to results of 3 yr of detailed biological data indicated that at the critical seasons an increase of ambient water temperature of 13°F introduced as a jet was satisfactory in meeting the temperature requirements of the fishes and associated organisms. An open circulating system is to be used with mechanical cooling towers to reduce the effluent from 21°F to 13°F above ambient. Low approach velocities at the cooling water screen structures are recommended to safeguard screenable fishes. (BBB)

**16116** ZORITA: THE FIRST NUCLEAR POWER PLANT IN SPAIN. Voysey, A. E. (Westinghouse Atomic Power Co. of Spain, Madrid). Atomwirt., Atomtech.; 14: 587-8(Dec 1969). (In German).

In Spain, the first nuclear power plant produced electricity in 1968. The pressurized water reactor, with a power of 160 Mw(e), was designed by Westinghouse and built in cooperation with local Spanish manufacturers. Characteristics of the reactor are presented in a table. Principal purposes of the first power plant are: training of personnel for future nuclear power stations; gaining of experience with management and economics of nuclear fuel; and service as a prototype for future improved nuclear plants needed by Spain. (H.B.G.)

**16117** PROBLEMS AND PROSPECTS FOR NUCLEAR POWER. Davis, W. Kenneth (Bechtel Corp., San Francisco). Chem. Eng. Progr.; 66: No. 2, 15-21(Feb 1970).

## Power Reactor Development

*Refer also to abstracts 14845 and 14977.*

**16118** (AEC-tr-6992) SOME PROBLEMS IN NUCLEAR POWER PLANT FUNCTION IN ELECTRICAL SYSTEMS. Dolezhal, N. A.; Koryakin, Yu. I. Translated from Seventh World Power Conference, Moscow, August 20–24, 1968. 15p. (CONF-680829-2). Dep. CFSTI.

Needs for electricity production and costs of this production in industrially developed countries are discussed. The costs of fossil-fuel and nuclear fired plants are compared. Problem areas for both types of plants are outlined. Proper utilization of thermal-fast reactor systems is discussed. (M.L.S.)

**16119** (AI-AEC-12792(Vol.1)) 1000-Mwe LIQUID METAL FAST BREEDER REACTOR FOLLOW-ON STUDY CONCEPTUAL DESIGN REPORT. VOLUME I. SUMMARY. (Atomics International, Canoga Park, Calif.). [nd]. Contract 31-109-38-1996. 89p. Dep. CFSTI.

For Argonne National Lab., Ill.

The final reference design for a 1000 MW(e) sodium-cooled fast breeder reactor is described. The reactor consists of a cylindrical core with 274 $PuO_2-UO_2$ fuel elements, 15 tantalum control rods, two rows of depleted $UO_2$ blanket elements, and a row of stainless steel reflector elements. The plant features 1140°F reactor outlet temperature, a "hockey-stick" configuration steam generator, a three-loop heat transfer system with one intermediate heat exchanger per loop, and a 3600-rpm tandem-compound turbine generator. A plant capital cost estimate, a fuel cycle cost analysis, and an overall economic assessment of the final reference design are presented. (H.D.R.)

**16120** (AI-AEC-12793) 1000-Mwe LIQUID METAL FAST BREEDER REACTOR FOLLOW-ON STUDY. TASK IV REPORT. RESEARCH AND DEVELOPMENT PROGRAM. (Atomics International, Canoga Park, Calif.). [nd]. Contract ANL 31-109-38-1996. 413p. Dep. CFSTI.

For Argonne National Lab., Ill.

The identification and definition of the research and development (R&D) program for the Atomics International (AI) design concept for a 1000 MW(e) liquid metal cooled reactor are detailed. The scope of the R&D program is defined, individual task costs are estimated, and priorities are assigned. (M.L.S.)

**16121** (EIR-163) GAS COOLED FAST REACTOR USING A DIRECT CYCLE GAS TURBINE. Lys, L. A.; Utzinger, E. (Eidgenoessisches Institut fuer Reaktorforschung, Wuerenlingen (Switzerland)). Oct 1969. 15p. (CONF-691018-1). Dep. CFSTI (U. S. Sales Only).

From 2nd International Fair and Technical Meetings for Nuclear Industries, Nuclex 69, Basel, Switzerland.

A design of a 1000 MWe gas cooled fast reactor using direct cycle gas turbines for power generation is presented. The fuel is mixed $PuO_2-UO_2$ in the form of metal clad fuel rods. It is shown that due to the inherently low fuel cycle cost characteristic

of this reactor type attractive performance figures can be obtained using can materials based on present day technology. (auth)

**16122** (GA-9400(Vol.3)) HTGR BASE PROGRAM, TASK I FY-69 DESIGN STUDIES FOR 1000 MW(e) HTGR POWER STATION. VOLUME III. STRUCTURAL DESIGN STUDIES. (United Engineers and Constructors Inc., Philadelphia, Pa. Gulf General Atomic, Inc., San Diego, Calif.). 30 Jun 1969. Contract AT(04-3)-167. 318p. Dep. CFSTI.

The effects of various structural options in the 1000 MW(e) High-Temperature Gas-Cooled Reactor reference design are assessed. The two general types of structures studied are (1) the Fort St. Vrain type reactor building and (2) the conventional pressure-containing secondary containment. The economics of construction and scheduling implications are evaluated, and the effect of tornado and seismic criteria of the site on the selection of construction methods is discussed. The effects of various construction methods (reinforced concrete, precast, prestressed concrete, and steel) for a typical reactor building are examined. Construction methods and materials investigated for the secondary containment include reinforced concrete, prestressed concrete, and steel. Based on the most desirable construction methods determined for the reactor building and containment vessel, the structural cost associated with each of three plant arrangements was determined. (H.D.R.)

**16123** (STI/PUB-164) INTERNATIONAL COMPARISON OF NUCLEAR POWER COSTS. Proceedings Series. Proceedings of the Symposium Held in London, 9-13 October 1967. (International Atomic Energy Agency, Vienna (Austria)). May 1968. 342p. (In French and English). (CONF-671089). IAEA $7.00.

Nuclear power plant construction and operation costs are discussed in detail. The general problems of cost extrapolation are considered on an international scale; the effects of local costs and variations are analysed. General organization of the conference is: General Problems of Cost Extrapolation; Extrapolation of Capital Costs; and Extrapolation of Fuel Costs. Separate abstracts are prepared for each of the 20 papers. (M.L.S.)

*For abstracts of individual papers see: 16090-16094, 16125-16130, 16192-16197, and 16207-16209.*

**16124** (TID-8200(21st Rev.)) NUCLEAR REACTORS BUILT, BEING BUILT, OR PLANNED IN THE UNITED STATES AS OF DECEMBER 31, 1969. (Office of the Assistant General Manager for Reactors (AEC), Washington, D. C.). 34p. Dep. CFSTI.

Information about facilities in the U. S. capable of sustaining a nuclear chain reaction is tabulated. The name of the facility is listed with location, principal nuclear contractor, type, power, and startup date. The facilities are categorized as: civilian reactors, production reactors, military reactors, reactors for export, and critical assemblies. (H.D.R.)

**16125** EFFECT OF METHODS OF FINANCING AND FISCAL SYSTEMS ON THE COST OF NUCLEAR POWER STATIONS. Falcon, P.; Rossignol, A. (CEA, Paris). pp 53-63 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968). (In French).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

In atomic matters the choices are not necessarily dictated by economic considerations; influenced by the desire to promote the development of nuclear science and technology on their territory, some countries prefer to construct power stations whose cost price is much larger than that of stations which they could import. Economic considerations and the desire for profitability are, however, not always absent from the decisions taken by governments, and govern those of industry. Among the factors which significantly affect the cost of power stations are methods of financing and fiscal systems, which vary not only from one country to another but even within one country. The regulations in force in various countries affecting the construction, import and export of nuclear power stations, are reviewed with regard to the diversity of these regulations and to the fact that they may affect the cost of power stations as much as do the technical or technological differences between reactor types. Only when there is a real international market for nuclear power stations can we hope for greater uniformity in the rules. (auth)

**16126** INFLUENCE OF TECHNICAL PERFORMANCE GUARANTEES ON THE DEVELOPMENT OF NUCLEAR POWER STATIONS. Bertonazzi, G.; Esclangon, P. A. G.; de Lacoste Lareymondie, M. L. P. G.; Renaudin, D. (Groupement des Constructeurs Francais de Centrales Nucleaires, Paris). pp 65-9 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968). (In French).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

In the case of conventional thermal power stations, the stage had been reached some time ago of fairly uniform contractual procedures as far as technical performance guarantees are concerned. The arrival of nuclear power stations upset this situation. The aim of the guarantees and the technical performance to which penalties were attached (net power; specific consumption; and, now, in the case of nuclear power stations, availability) are discussed. The specific consumption penalty usually corresponded, in the case of conventional power stations, to the extra expenditure on fuel during one year of operation; this period has been extended to more than 10 years for certain nuclear power stations. The availability guarantee constitutes a particularly serious risk for the suppliers in that it raises problems of the division of liability between builders and operators, which are difficult to resolve. The guarantee of operation and maintenance costs and of the lifetime of power station are also examined. The significance of extending guarantees and raising penalties, which impose on suppliers construction margins and margins of risks which lead to price increases are stressed. (auth)

**16127** ASSESSMENT OF COSTS OF ALTERNATIVE PLANT PROPOSALS ON THE CEGB SYSTEM. Berrie, T. W.; Betts, P. E. (Central Electricity Generating Board, London). pp 71-9 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Daily and annual load shapes for Great Britain are discussed; the different types of generating plant required to match the load shapes and the spectrum of operating costs making up the merit order of generator loading are considered. Within this background the various different types of generating plant have cost characteristics which have advantages and disadvantages. The nuclear plant is examined with special reference to its required flexibility of operation in the future system. The operation of the most probable composition of the future system is simulated to enable the operating regimes of existing and proposed new plant to be estimated over a period corresponding to the economic lives of the new plants. The same simulations enable probable incremental operating costs to be determined for the inclusion of the various different types of plant. The detailed methods developed by the Central Electric Generating Board for assessing the economic worth of alternative individual proposals for generating plant projects of varying types to make up plant extension program are described. (auth)

**16128** EFFECT OF LOCAL CONDITIONS ON THE CHOICE OF NUCLEAR INVESTMENTS FOR AN ELECTRICITY PRODUCER. Janin, R. (Electricite de France, Paris). pp 81-97 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968). (In French).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Since nuclear energy proved itself from the technological point of view, its possibilities of application and the methods of developing it are being investigated. Thus it is tempting to find out what might be the best technical solutions, now and in the future, by examining the problem in its very general aspects. For the electricity producer who is mainly interested in production costs, the problem is slightly different; local conditions, both technical and economic, take precedence over all other considerations. Each system of production has its own peculiar characteristics: size, the proportion of hydroelectric power, the regime of rivers, existence of reservoirs, etc., are parameters which can affect the utility of introducing a nuclear power station into the system. Furthermore, the cost structures of countries can vary within very wide limits, which makes it impossible to arrive at a general order of merit for the various types. Transposition of costs between countries using rates of exchange gives results which may be erroneous; this phenomenon is especially noticeable in the developing countries. The financing of investments plays a major role in the choice: depending on whether he can call on a financial market or obtain a loan from the World Bank or payment facilities from the suppliers, the producer will take very different decisions. In countries where there is a development plan or even some degree of governmental control over the economy, the criteria will also include the growth rate of the economy. For all these reasons it seems essential for electricity producers to make their decisions after detailed analyses of the particular conditions obtained in the country; international comparisons must therefore be interpreted with caution. 15 references. (auth)

**16129** EXTERNAL SAVINGS AND NUCLEAR ENERGY. Gaussens, J.; Bonnet, R. (CEN, Fontenay-aux-Roses, France). pp 111-22 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968). (In French).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

It is essential for a producer of electricity to combine adequate production facilities with minimum investment and lowest possible cost per kWh. For a state the situation is different: account must be taken, in the context of the national policy, of external factors—economic and social—which are linked to the conditions of power production and are not usually included in the notion of cost. Some examples of external savings, particularly with reference to nuclear power though also making comparisons with fossil-fueled power, are considered. Starting from those effects which have already been the subject of quantification studies, e.g., reliability of supply, the study of definite but more indirect effects are discussed. The object has been to define the indirect specific advantages of nuclear power and to quantitate them so that they may become decisive factors when determining as rational a nuclear policy as possible. 8 references. (auth)

**16130** FACTORS AFFECTING COSTS OF EXPORT NUCLEAR POWER STATIONS. Bainbridge, G. R. (United Kingdom Atomic Energy Authority, Risley, Eng.); Pashley, D.; Rowlands, D. T. H.; Wagstaff, C. V. pp 139-54 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Consideration is given to those factors which affect the capital cost and other fixed charge items affecting the generating cost of UK export nuclear power stations constructed in association with customers overseas. In each of four main areas, namely prime-costs, contractor's oncosts, customer's oncosts and operations the items are considered which would give rise to a range of station prices. It is not important for a customer to spend large sums of money in obtaining very detailed expertise in nuclear power station design and operation. The customer or his consultants should, however, have developed to the stage where a thorough comparative assessment of the alternative types of power station available or offered can be made. They should be prepared to assess the engineering of the plant from the reliability and availability aspects: they will need to consider the safety and public relations problems objectively; they will need to be capable of understanding the margins built into the plant and the possible development of that and future plants of a similar type. These things must be clarified to the satisfaction of a customer before he signs any contract. (auth)

**16131** ISO CODES FOR NUCLEAR REACTOR PRESSURE VESSELS. Com. Naz. Energ. Nucl., Notiz.; 15: No. 10, 81-4 (Oct 1969). (In Italian).

The activities of the International Standards Organization (ISO) are discussed with respect to reactor pressure vessels. The considerations involved in developing standards are discussed. Materials, fabrication, and operations acceptability are considered. (M.L.S.)

**16132** PEACEFUL USES OF NUCLEAR ENERGY. Com. Naz. Energ. Nucl., Notiz.; 15: No. 10, 61-8(Oct 1969). (In Italian).

The overall power reactor program is summarized for the whole world. Electricity production by power reactor is tabulated for 1968 according to country of the western world. Cost of electricity production is compared tabularly for Great Britain; the fuel cycle cost is taken into consideration. Overall cost and benefits of nuclear power are discussed. (M.L.S.)

**16133** FISSILE MATERIAL IN A FAST REACTOR. Sens, P. F. Atoomenergie Haar Toepass., 11: 233-7; 240-2(Oct. 1969). (In Dutch).

The fission processes and breeding ratios in fast reactors are discussed. Problems encountered in the transport of spent fuel for fast reactors are considered. Fuel cladding and coolant effects on breeding rate are discussed. (M.L.S.)

**16134** DOUNREAY PROTOTYPE FAST REACTOR. Outram, W. J. Electron. Power; 16: 43-7(Feb 1970).

The 1.5 MW experimental fast reactor at Dounreay has been operating since 1959. The UKAEA is now building a 250 MW prototype fast reactor there, which is due for completion in 1972, and should act as a stepping stone to the design and construction of large commercial fast reactors. (auth) (UK)

**16135** NUCLEAR ENERGY AND ITS ROLE IN TECHNICAL PROGRESS. Alexandrov, A. (Inst. of Atomic Energy, Moscow). Energ. Nucl. (Paris); 11: 549-51(Dec 1969). (In French).

Developments in efficient power reactor design are reviewed. Requirements for future reactor designs are described. The importance of fast breeder power reactors is discussed. (D.C.C.)

**16136** MARK-3 HIGH-TEMPERATURE REACTOR. McLaren, Norman H. Ind. At.; 13: No. 11-12, 37-46(1969). (In French).

In the United Kingdom, the high-temperature, He-cooled G. C. R. reactor is known as the Mark-3, while Magnox and A. G. R. are called respectively Mark-1 and Mark-2. Stages in the development of the reactor and of its fuel are reviewed. The array of data which enable the United Kingdom to look forward to an early construction of the Mark-3 reactor is described, and its characteristics are outlined. (auth)

**16137** IMPORTANCE, PLANNING, DEVELOPMENT, ECONOMIC FEASIBILITY, AND USE OF NUCLEAR ENERGY FOR UNDERDEVELOPED COUNTRIES WITH A SPECIAL REFERENCE TO PAKISTAN. Rahman, Inam-ur. Raleigh, N. C.; North Carolina State Univ.(1969). 526p.

Thesis.

Some problems of economic growth are discussed for various underdeveloped regions of the world. Special emphasis is given to the role of energy in development. Japan is taken as a model of development for most of the underdeveloped countries. Distribution of fossil and nuclear fuel resources in various regions of the world is discussed. Current methods of energy production are described along with their advantages and limitations. Various types of nuclear reactors available commercially are examined in detail and a brief discusssion is given regarding some future reactor concepts. Management and utilization of various types of nuclear fuels presently used, or expected to be used, are considered. Economic feasibility of nuclear power reactors of all sizes is given and an effort is made to give a rough evaluation for the prospects of nuclear energy with other energy sources under different conditions. Influence of various factors such as reactor size, type, plant factor, fossil fuel costs, cost of money and nature of fuels on the competitiveness of nuclear energy are discussed. Desalination of water using nuclear energy and cost trends of desalinated water using single and dual-purpose desalination plants are described. Possible influence of recovery of chemicals from the concentrated brine on desalinated water costs is also given. Additional applications of nuclear energy for food pasteurization and sterilization, industrial production, and medical diagnosis and treatments, are discussed in some detail. Various steps and problems expected to emerge during the planning and development stages of nuclear power programs are presented: future role of nuclear energy; manpower assessment and training; siting and safety problems of nuclear reactors; problems of radioactive waste disposal; inclusion of nuclear power systems in the existing electric networks; as well as the establishment of an integrated nuclear power industry in a country are discussed in detail. A critical review is given of various types of small nuclear reactors essential for training and research purposes. Pakistan is taken as a typical example for study of future prospects of nuclear energy. A brief review is given of the country as well as its primary sources of energy. The existing and expected electrical energy sources are compared with the expected energy requirements in the future. All other applications of nuclear energy are also discussed in various regions of East as well as West Pakistan. A brief review is given of the future of nuclear energy in other countries. (Diss. Abstr.)

**16138** THE U. S. FAST BREEDER PROGRAM. THE PAST AND PRESENT STATUS. Yevick, John (Atomic Energy Commission, Washington, D. C.). Energ. Nucl. (Paris); 11: 463-9 (Nov 1969). (In French).

Breeder reactor development in the U. S. is traced from the EBR-I. Principles of safety, reliability, and economy under assessment are described. The Liquid Metal-Cooled Fast Breeder Reactor program is outlined. (H.D.R.)

**16139** THE FUTURE OF THE U. S. FAST BREEDER REACTOR PROGRAM. Shaw, Milton (Atomic Energy Commission, Washington, D. C.). Energ. Nucl. (Paris); 11: 470-6(Nov 1969). (In French).

The U. S. Liquid Metal-Cooled Fast Breeder Reactor (LMFBR) program is reviewed. Phases of the LMFBR program discussed in detail include: (1) research and development; (2) demonstration plants; (3) commercial LMFBR plants; and (4) supporting test facilities. (H.D.R.)

**16140** ATOMICS INTERNATIONAL FAST BREEDER REACTOR DEMONSTRATION PLANT PROGRAM. Siegel, Sidney

(North American Rockwell Corp., Canoga Park, Calif.). Energ. Nucl. (Paris); 11: 477-84(Nov 1969). (In French).

Engineering and development of a sodium-cooled 400 MW(e) fast breeder demonstration reactor is progressing at Atomics International in collaboration with General Public Utilities. Preliminary designs and safeguard analyses have been completed. The plant comprises a three-loop piped heat transfer system, housed in a double-barrier containment structure. The steam generator is of a simple modular design. Fuel elements, using mixed U–Pu oxide fuel, include novel features to cope with material swelling phenomena. In later 1,000 MW(e) commercial plants based on this design, a fuel cycle cost of 0.7 mill/kWh is estimated, with a system doubling time of about 10 years. (auth)

**16141** GAS COOLED FAST BREEDER REACTORS. Melese-d'Hospital, Gilbert (Gulf General Atomic Inc., San Diego, Calif.). Energ. Nucl. (Paris); 11: 485-92(Nov 1969). (In French).

Gas Cooled Fast Breeder Reactors have been studied since 1961 and a 330 MW(e) demonstration power plant is presently under design at Gulf General Atomic Incorporated. Besides utilizing well-known gas cooling technology, GCFR with metal-clad $UO_2$–$PuO_2$ fuel will benefit from the physics and fuel development programs of Liquid Metal Fast Breeder Reactors. Helium cooling brings improved neutron economics and at the same time, avoids the many highly specialized and rigorous engineering requirements associated with liquid metal handling. This results both in easier maintenance and reduced cost of plant and associated equipment. Future developments, such as carbide fuel and direct cycle gas turbine, promise to further improve GCFR performance and to lead to still lower costs. (auth)

**16142** DEVELOPMENT OF A COMPETITIVE FAST BREEDER. Storrs, C.-L.; Dietrich, J.-R. (Combustion Engineering Inc., Windsor, Conn.). Energ. Nucl. (Paris); 11: 493-8 (Nov 1969). (In French).

The fast breeder reactor type will have a much more difficult time competing with alternative means of power generation than is frequently assumed. To be a commercial success, an FBR must have high breeding performance and low fuel cycle cost, and must answer all safety questions without settling for degraded plant performance. The key to accomplishing these things lies in the selection of a fuel with high performance capabilities: uranium–plutonium carbide, sodium-bonded and vented. A high performance demonstration plant using this fuel could be committed in 1975. (auth)

**16143** WESTINGHOUSE LMFBR PROGRAM. Kelly, C. R. Jr. (Westinghouse Electric Corp., Madison, Pa.). Energ. Nucl. (Paris); 11: 499-507(Nov 1969). (In French).

Westinghouse Electric Corporation has been active in the development of sodium-cooled fast breeder reactors since the early 1950's through its activities in support of the Fermi Project and the Liquid Metal Fast Breeder Reactor program. Westinghouse activity in this area has increased greatly since the creation of the Advanced Reactors Division in 1966. It now has the staff and facilities necessary to implement a substantial portion of the U. S. LMFBR Program and has initiated work in a number of critical problem areas including steam generator development. Because of these capabilities Westinghouse Electric Corporation is in an excellent position to design and develop an LMFBR Demonstration Plant for operation in the mid-1970's (auth)

**16144** DEVELOPMENT OF THE LMFBR AT BABCOCK AND WILCOX. Croft, Melbourne W. (Babcock and Wilcox Co., Lynchburg, Va.). Energ. Nucl. (Paris); 11: 508-12(Nov 1969). (In French).

By producing more fuel than it consumes the LMFBR can meet world power requirements at low cost price and in large quantities. At present, the use of the LMFBR is spreading throughout the world. The position occupied by the LMFBR in the United States is examined. The main activities that it engenders within the Babcock and Wilcox group, one of the five large suppliers of parts and tools for the LMFBR, are outlined. The typical project for the 1,000 MW(e) B & W LMFBR is described. (auth)

**16145** DEVELOPMENT OF FAST BREEDER REACTORS IN U. S. A. Fenech, Henri (Univ. of California, Santa Barbara). Energ. Nucl. (Paris); 11: 513-18(Nov 1969). (In French).

The history of fast breeder reactors in the United States is discussed. In the past years a systematic approach coordinated by the A.E.C. has been undertaken by reactor manufacturers and electrical companies. The prototype 250 and 1,000 MW(e) power station projects are compared. The role of the universities in this program is stressed. (auth)

**16146** STUDY OF A REFERENCE PLANT. Cicognani, Gianfranco. Com. Naz. Energ. Nucl., Notiz.; 14: No. 8-9, 180-98(Aug-Sep 1968). (In Italian).

The overall program for the development of nuclear power in Italy is discussed. Results of fuel cycle economic evaluations and economic impact on the nuclear industry are discussed. Economics of scale are considered. The economic effects of core characteristics and design parameters are considered. (M.L.S.)

**16147** PEC REACTOR. Aiello, Paolo; Zona, Rinaldo. Com. Naz. Energ. Nucl., Notiz; 14: No. 8-9, 150-79(Aug-Sep 1968). (In Italian).

The overall program for the design, construction, and utilization of the PEC Fast Test Reactor is summarized; the reactor facility is then described. The core, fuel handling system, primary and secondary circuits, and experiment facilities are described. Characteristic design parameters are tabulated. The site on which the reactor is being built is described. (M.L.S.)

**16148** GASEOUS-CORE REACTOR CONCEPT FOR ELECTRICAL POWER GENERATION. Gritton, Eugene C.; Pinkel, Benjamin (Rand Corp., Santa Monica, Calif.). Nucl. Appl. Technol.; 8: 355-70(Apr 1970).

The feasibility of the application of the gaseous-core reactor to electric-power-generation systems is discussed. An analysis of the radiation-heat-transfer process in the gaseous-core is presented. The results of this analysis are then combined with an estimate of the quantity of U required for criticality to determine the core pressure and temperature for various values of power generation and core diameters. This analysis indicates that attractive power levels in reactors of practical size can be obtained with gas pressures and wall temperatures within the potential capability of known structural materials. As an example, it is estimated that a spherical gaseous-core reactor with a radius of 152.4 cm would generate about 4,000 MW(t) with a gas pressure of about 11 atm. Several configurations of the gaseous-core employing thermionic converters and heat pipes are described. (auth)

**16149** NUCLEAR POWER: 1970–80. Reichle, Leonard F. C. Pub. Util. Fortn.; 85: 36-43(12 Feb 1970).

Predictions for nuclear power in the 1970 decade are made. Capital costs and differential costs are compared for nuclear and fossil-fired plants. Location of the nuclear power plants and fuel supplies are considered. (M.C.S)

**16150** NUCLEAR PLANT AND OUR ENERGY NEEDS. Seaborg, Glenn T. (Atomic Energy Commission, Washington, D. C.). Pub. Util. Fortn.; 85: 19-26(12 Feb 1970).

The needs for electrical power are considered from the standpoint of social requirements and living conditions. Sources of energy are discussed. The impact of energy production on environment is assessed with respect to minimization. The public resistance to nuclear power is discussed. The role of the AEC is described with relation to its nuclear power activities. (M.L.S.)

**16151** THE INTERNATIONAL OFFERING OF THE ATOMIC INDUSTRIES. REPORT ON THE NUCLEX 69 FROM 6–11 OCTOBER IN BASEL. Atomwirt., Atomtech.; 14: 589-611(Dec 1969). (In German).

The exhibits indicating the products and services offered by the participants in Nuclex 69 are described. Brief summaries are presented of industry offerings in: (1) nuclear power plant construction; (2) reactor components, technical nuclear accessories, and construction materials; (3) reactor instrumentation; (4) fuel cycle services; (5) radiation measurement techniques; and (6) radioisotopes, irradiation equipment, and isotope-powered batteries. (H.D.R.)

**16152** FUEL SYSTEM FOR A FAST LIQUID METAL-COOLED NUCLEAR REACTOR. Gumuchian, A.; Migadel, M.; Sauvage, M. (to Commissariat a l'Energie Atomique). Canadian Patent 828,950. 2 Dec 1969. Priority date 22 Jul 1965, France.

A sealed vessel is provided with at least one intake conduit and a lateral discharge conduit for the liquid metal. The system consists of a lower tubular case containing fuel material which is disposed vertically in the bottom part of the vessel beneath the level of the discharge conduit, and an upper part of neutron-absorbent material. This comprises an absorbent mass of the same section as the lower case and which, when the systems are in position, forms a continuous screen to prevent neutron leakage to the top of the reactor. It also cooperates with the case to form a liquid metal header at the discharge conduit. The absorbent masses are disposed above elements of reduced section which absorb the neutrons in the header at the level of the discharge conduit while allowing the liquid metal to pass. (F.S.A.)

**16153** OPTIMUM CONSTRUCTION METHOD OF HEATING SYSTEMS BASED ON A FUNDAMENTAL NUCLEAR HEAT SOURCE. Bortlik, Jiri (Vyzkumny Ustav Energeticky, Prague). Energetika; 19: 485-8(Dec 1969). (In Czech).

The problem of utilizing nuclear heat sources lies in determining the most useful construction schedule for a centralized heat supply system in which a nuclear plant supplies the basic heat load. The results of a calculation for the optimum date for placing the nuclear plant into operation are presented. The principles for correct technical and economic evaluation are analyzed. 4 references. (auth)

**16154** SYSTEMIZATION TECHNIQUES FOR NUCLEAR POWER PLANT SYSTEMS. Mathe, Ivan Gyoergy. Energ. Atomtech.; 22: 143-54(Mar 1969). (In Hungarian).

Systemization techniques in designing nuclear power plant systems are analyzed. A brief review is given of economics, applicability, and technological characteristics of various types of nuclear power plant systems. Construction and performance of separate units of power plants are examined and evaluated at optimum performance conditions. (R.V.J.)

## *Kinetics and Dynamics*

*Refer also to abstracts 16305 and 16313.*

**16155** (BNL-50117) PROCEEDINGS OF THE BROOKHAVEN CONFERENCE ON INDUSTRIAL NEEDS AND ACADEMIC RESEARCH IN REACTOR KINETICS, APRIL 8-9, 1968. (Brookhaven National Lab., Upton, N. Y.). Jul 1968. 468p. (CONF-680414). Dep. CFSTI.

Separate abstracts are included for 16 of the 21 papers presented. Summaries only appear for 2 of the papers. Three papers have appeared previously in NSA and may be located in the Report Number Index under CONF-680414. (D.C.C.)

*For abstracts of individual papers see: 16156-16161, 16173, 16271-16274, 16300, 16301, and 16304-16306.*

**16156** (BNL-50117, pp 1-36) REACTOR KINETICS EFFECTS OF SIGNIFICANCE TO LARGE BOILING WATER REACTOR DESIGN AND OPERATION. Crowther, R. L.; Fischer, D. L.; Niemi, R. O.; Wood, J. E. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.).

Methods of analysis and experimental results for reactor kinetics are presented. Topics discussed include: coupled nuclear-thermal-hydraulic stability; plant operational transients; xenon transients; prompt reactivity induced power bursts; reactor noise; and fuel depletion transients. (13 references) (D.C.C.)

**16157** (BNL-50117, pp 77-85) INDUSTRIAL NEEDS IN FAST REACTOR KINETICS. Gyorey, G. L. (General Electric Co., Sunnyvale, Calif. Advanced Products Operation).

A review of experimental and theoretical programs for the development for fast reactors is presented. (10 references) (D.C.C.)

**16158** (BNL-50117, pp 86-96) ACADEMIC-INDUSTRIAL RELATIONSHIPS IN LMFBR REACTOR KINETICS. Heck, F. M.; Poncelet, C. G.; Wright, J. H. (Westinghouse Electric Corp., Pittsburgh, Pa.).

Industrial needs in LMFBR kinetics where academic institutions might participate and contribute are reviewed. (4 references) (D.C.C.)

**16159** (BNL-50117, pp 265-74) DEVELOPMENTS IN REACTOR KINETICS REQUIRED FOR THE LMFBR. Butler, D. K.; Rose, D. (Argonne National Lab., Ill.).

Topics discussed include: time-dependent neutron population static calculations; reactivity coefficients; long-term time-dependent changes; control systems; physical changes; and safety analysis. (8 references) (D.C.C.)

**16160** (BNL-50117, pp 275-305) ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF THE KINETIC BEHAVIOR OF $UO_2$-FUELED PRESSURIZED WATER REACTOR. Grund, J. E.; Houghtaling, J. E. (Phillips Petroleum Co., Idaho Falls, Idaho).

Results of programs related to light-water-moderated, low enriched $UO_2$-fueled power reactors are presented. Topics described include: analytical predictions of reactor kinetic response using the PARET computer code; fuel performance predictions using experimental results from subassembly tests in the Capsule Driver Core in the Spert 4 facility; and integral reactor excursion tests using a low-enriched $UO_2$ core in the Spert 3 pressurized-water reactor facility. (18 references) (D.C.C.)

**16161** (BNL-50117, pp 365-79) STABILITY OF THE CANDU-BLW SYSTEM. Critoph, E. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

Design parameters of the 250 MW(e) prototype CANDU-BLW are listed. Stability of the reactor systems is described. (D.C.C.)

**16162** (DOCKET-50171-24) [PEACH BOTTOM ATOMIC POWER STATION, UNIT 1]. Request for Authorization of Facility Change and Associated Technical Specification Changes (No. 12 and 13). (Philadelphia Electric Co., Pa.). 20 Feb 1970. 8p. Dep. CFSTI.

Changes in Technical Specifications to reflect replacement of the Peach Bottom Power Reactor, Unit 1 core 1 by core 2. New stationary fuel elements are described; control rod reactivity worths are prescribed. Average fuel burnups are specified for core 2. The core component surveillance schedule is tabulated. (M.L.S.)

**16163** (KFKI-31/1969) NOVEL MEASURING UNIT WITH INTEGRATED CIRCUITS FOR TIME DISTRIBUTION MEASUREMENTS IN REACTOR PHYSICS. Palmai, I.; Hubert, B. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). 1969. 9p. Dep. CFSTI (U. S. Sales Only).

The design of a time distribution measuring unit for reactor physics measurements is described. The decay of a neutron pulse, injected into the core, is measured in a time analysis mode; Rossi-$\alpha$, rod drop, multidetector, and Feynman-type measurements with this integrated circuit-multichannel analyzer instrumentation are discussed. (M.L.S.)

**16164** REACTIVITY FEEDBACK WITH SHORT DELAY TIMES. Koehler, Walter H. (Kernforschungszentrum, Karlsruhe, Ger.). J. Nucl. Energy; 23: 569-74(1969).

Analytical expressions based on the point reactor model are presented for the increase in peak power, temperature and energy release, caused by short time delays in the temperature feedback of reactivity, in super-prompt critical excursions. A criterion is presented to decide whether the delay time should be included in the analysis. Two specific cases, slowing-down delay and heat transfer delay of Doppler feedback in Na cooled fast breeder reactors are discussed. (auth)

**16165** STATUS OF NEUTRON CROSS-SECTIONS IN REACTOR TECHNOLOGY. Garg, S. B. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 321-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The status of neutron cross-sections as applied to the feasibility, economics, safety and the shielding studies of fast reactors is reviewed. 6 references. (auth)

**16166** CALCULATION OF RESONANCE ESCAPE PROBABILITY FOR HEAVY WATER MODERATED LATTICES. Nakra, A. N. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 361-4(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

**16167** THEORETICAL ANALYSIS OF EXPERIMENTAL MEASUREMENTS OF SINGLE ROD NATURAL URANIUM HEAVY WATER LATTICES. Bhatia, H. K.; Balakrishnan, Kamala (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 382-5 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Two methods are described for making lattice calculations for heavy water moderated reactors. The methods consist of the computer codes DUMLAC and CAROL. A comparison of experimental data and computer code results is presented. 2 references. (D.C.C.)

**16168** ABSOLUTE MEASUREMENTS OF $^{238}U$ CAPTURE AND $^{239}Pu$ FISSION RATES IN FAST REACTORS. Chawla, R.; Besant, C. B. (Imperial Coll. of Science and Tech., London). J. Brit. Nucl. Energy Soc.; 9: 28-36(Jan 1970).

Techniques for the absolute determination of $^{238}U$ capture and $^{239}Pu$ fission rates in a fast reactor assembly were developed. The effective reaction rate ratios derived from these absolute measurements were found to agree within 2% with those obtained using the standard thermal-comparison technique which tends to confirm the absence of any unsuspected systematic error in either method. It is shown that the absolute technique has a greater potential accuracy in the determination of this reaction

rate ratio than is possible with the thermal-comparison method. (auth) (UK)

**16169** ACCURACY OF POWER-DISTRIBUTION CALCULATION METHODS FOR URANIUM AND PLUTONIUM LATTICES. Ariemma, A.; Lesnoni La Parola, G.; Paoletti Gualandi, M.; Peroni, P.; Zaffiro, B. (Ente Nazionale per l'Energia Elettrica, Rome). Nucl. Appl. Technol.; 8: 328-54(Apr 1970).

Under the joint ENEL-EURATOM program for the utilization of plutonium in thermal reactors, the power distribution calculation methods used by ENEL were subjected to extensive investigation aiming at ascertaining their adequacy in handling the various aspects of $UO_2$ and $PuO_2$ cores. Two categories of codes were verified by comparison with experimental data: (1) Codes that permit the determination of the macroscopic power distribution of the whole core as a function of irradiation, namely, FLARE and CONDOR. The calculated data were found to compare favorably with the experimental observations. (2) Codes that permit the assessment of the effect of local nonuniformities on power distribution over the fuel lifetime, namely, the BURNY code in the two-group and in the five-group (two thermal and three fast) versions. The three-group BURNY version generally gave a slightly better agreement with the actual power distribution while the $^{239}Pu$ and $^{235}U$ fission rate ratios were evaluated better by the two-thermal-group versions. Since allowance was made for the spectrum softening due to the water gap, the GAM-THERMOS-SQUID system achieved the same accuracy as the two-thermal-group BURNY, but it was much more time-consuming. However, the two-thermal-group version of the BURNY code tended to overestimate the effect of the water gap on the corner rod slightly, and the one-group version underestimated it. (auth)

**16170** PRODUCTION OF COLD NEUTRONS. Ergenc, S. (to Sulzer Brothers Ltd.). Canadian Patent 830,150. 16 Dec 1969. Priority date 5 Jul 1965, Switzerland.

The method consists of compressing a gas of low boiling point, cooling and liquefying it by countercurrent heat exchange flow with previously compressed and subsequently expanded gas. It is supercooled by evaporation of a fraction of the condensed gas expanded to intermediate pressure. The next step is to pass the supercooled gas through the moderator of a nuclear reactor, evaporating and superheating the liquefied gas emerging from the moderator by passing it in countercurrent heat exchange flow with newly compressed gas. Then the evaporated and superheated gas is expanded with the performance of external work and combined with the fraction as evaporated in the supercooling step and further heating the resulting combined gas stream to the vicinity of ambient temperature preliminary to renewed compression. The system operates without a pump. Apparatus for operating such a cycle is described. (F.S.A.)

**16171** UNCERTAINTIES IN THE CALCULATIONS OF THE EFFECTIVE MULTIPLICATION CONSTANT IN PEBBLE BED REACTORS. Massimo, L.; Schmid, U. A. (Brown Boveri/Krupp Reaktorbau GmbH, Mannheim, Ger.). Atomkernenergie; 15: 53-5(1970). (CONF-690419-8).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

The uncertainties in the calculation of the effective multiplication constant in pebble bed reactors are analysed together with the resulting uncertainty in the attainable burn-up. Each source of error is separately analysed and the total inaccuracy is then calculated supposing a normal Gauss distribution for every single uncertainty. 5 references. (auth)

**16172** FAST AND SLOW TRANSIENTS IN HIGH TEMPERATURE REACTORS. Friedrich, K. (Brown Boveri/Krupp Reaktorbau GmbH, Mannheim, Ger.); Massimo, L.; Vincenti, E. Atomkernenergie; 15: 35-8(1970). (CONF-690419-6).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

Two computer codes for one-dimensional fast and slow transient calculations are described. The first one is intended for accident analysis, while the second one calculates the Xe transients in order to analyze the capability of a reactor to follow a given power diagram. The results are compared with those obtained from zero-dimensional calculations. 3 references. (auth)

## Control Systems

*Refer also to abstracts 14351 and 14352.*

**16173** (BNL-50117, pp 347-64) METHODS FOR THE STUDY OF THE CONTROL OF NATURAL URANIUM, GRAPHITE, GAS-COOLED REACTORS. Bacher, P.; Cailly, J. L. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires).

The control of natural-uranium-fueled, graphite-moderated, gas-cooled reactors is analyzed. Methods used for control analysis are described. Examples of computer program calculation methods are included. (5 references) (D.C.C.)

**16174** (WCAP-3680-9) CONTROL OF XENON INSTABILITIES IN LARGE PWR'S. Quarterly Progress Report for the Period Ending December 31, 1968. O'Boyle, M. J. (Westinghouse Electric Corp., Pittsburgh, Pa. PWR Systems Div.). Jan 1969. Contract AT(30-1)-3680. 12p. (EURAEC-2080). Dep. CFSTI.

Work Performed under United States-Euratom Joint Research and Development Program.

The characteristics and control of spatial instabilities in large pressurized water reactors was investigated. Work on the effect of core parameters on spatial oscillations and on remedial control procedures has been completed and is described in topical reports. Work on three-dimensional calculations of spatial instabilities with conditions conducive to oscillations is in progress. (H.D.R.)

**16175** NUCLEAR REACTOR SYSTEM. Yevick, John G.; Brill, Edward F. (to Atomic Power Development Associates, Inc.). U. S. Patent 3,488,253. 6 Jan 1970. Filed 30 Oct 1967.

This invention relates to apparatus for introducing neutron absorbing fluid into the core region of a nuclear reactor and means for controlling the quantity of such fluid therein. (Offic. Gaz.)

**16176** HYDROGEN-DIFFUSION REACTOR CONTROL. Magladry, R. (to Martin Marietta Corp.). Canadian Patent 827,848. 18 Nov 1969.

A self regulating mechanically passive control system having a main reactor section including core and reflector is described. The system consists of a control rod of hydride material fixed with respect to the main reactor section with one end disposed within the core and the other extending outside the core. Reactor fuel is also incorporated within the end of rod placed internally in the core. Several such rods are used and thus it is seen that a fuel rod and control are incorporated into one unit. There are electrical means for producing a temperature differential between the two ends of a rod and thereby vary the hydrogen concentration between the respective ends of each rod. This provides the basis for reactivity control. Procedures for startup, shutdown and power variations are outlined. Coolant circulation through the core is conventional and may be varied to suit conditions. (F.S.A.)

## Shielding

**16177** (JPRS-49745) PROBLEMS IN THE PHYSICS OF REACTOR SHIELDING. Broder, D. L.; Suvorov, A. P.; Tsypin, S. G. (eds.). Translation of selected papers from Voprosy Fiziki Zashchity Reaktorov, Atomizdat, Moscow, 1969. 210p. CFSTI.

Sixteen articles are included on the physics aspects of reactor shielding optimization. The space, energy, and angular distributions of radiations in homogeneous and inhomogeneous shields are analyzed. Shielding properties of various materials are presented. An abstract of the papers from the original language appears in NSA 23: 46527. (H.D.R.)

## Cooling Systems

*Refer also to abstracts 14337, 14338, and 14365.*

**16178** (CEA-R-3893) REMARKS CONCERNING THE DETERMINATION OF BURN-OUT IN RESEARCH REACTORS. Fabrega, Serge; Lafay, Jacques; Vernier, Philippe (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Nov 1969. 34p. (In French). Dep. CFSTI (U. S. Sales Only).

The experimental problems associated with the measurement of critical burnout are discussed. The experimental setup for heat transfer measurements in the PECASE research reactor is described. The difference between localized and gross boiling is described; effects of both types of burnout are considered. Results of data are shown graphically. 20 references. (M.L.S.)

**16179** (EUR-4280(Vol.1), pp 135-56) PRESTRESSED CONCRETE PRESSURE VESSELS WITH HEATED SIDES. Tarbes, B. (Societe d'Etudes et d'Equipments d'Entreprises, Paris (France)). (In French).

The present prestressed concrete pressure vessels are compared with the advanced conceptual designs. This comparison includes a description of the experimental study of the hot-wall prestressed concrete pressure vessel. This hot-wall system con-

sists of the liner with its strutting to protect the hot concrete from all contact with the fluid, the hot concrete which has the role of heat resistor, the cooling circuit which is buried in the concrete and removes most of the heat crossing the hot concrete, and the prestressed concrete. The hot concrete is fabricated with a binder which contains no sulfoaluminates. The behavior of the hot concrete under high temperature is analyzed; the relaxation behavior and thermal conductivity measurements are discussed. The testing of materials for the steel liner and the testing which is still needed to evaluate the system are described. A system using the heated concrete at very high pressures is outlined. (J.S.R.)

**16180** (EUR-4280(Vol.1), pp 225-51) MULTILAYERED PRESTRESSED CONCRETE PRESSURE VESSELS. Bremer, F. (Fried-Krupp Universalbau, Essen (West Germany)). (In German).

The concept of dividing the thick-walled pressure vessel into several layers with each layer having its special physical function was proposed. Theoretical studies were made using the date and dimensions of a reference reactor developed by Euratom. The vapor pressure of capillary tubes, water balance of evacuated concrete, temperature distribution with internal insulation and with external insulation, and two- and three-dimensional concrete strengths were calculated. The computer program for the three-dimensional stress analysis was given. (J.S.R.)

**16181** (EUR-4280(Vol.1), pp 341-54) MODEL TESTING OF PRESTRESSED CONCRETE PRESSURE VESSELS FOR A 300 MW HIGH TEMPERATURE REACTOR. Eberle, K.; Schmiedel, F. (Brown Boveri/Krupp Reaktorbau G.m.b.H., Mannheim (West Germany)). (In German).

A 1:20 scale model of a pressure vessel for the Thorium High Temperature Reactor with spherical fuel elements was constructed to test pressure vessel calculations. The construction of the model and the test techniques are described. The model was tested at a pressure of about 50 atm with the actual operational pressure of 40 atm planned for the high temperature reactor. The pressure study on the hot pressure vessel up to 116 atm was carried out about 8 weeks after the initial stress and a week later the rupture tests were made. In the heat studies, the pressure vessel showed an elastic behavior in the pressure range up to 116 atm. The destruction of the model pressure vessel occurred at 4.8 times the operational pressure. The test results showed the significant safety reserve of a prestressed concrete pressure vessel at high pressure increase. (J.S.R.)

**16182** (EUR-4280(Vol.1), pp 393-416) PRESTRESSED CONCRETE PRESSURE VESSEL WITH A METAL COVER FOR A 1000 MWe BOILING WATER REACTOR. Boggio, G. (European Atomic Energy Community); Happich, J. P. (Societe d'Etudes et d'Equipments d'Entreprises, Paris (France)). (In French).

The characteristics of a reference design using a prestressed concrete vessel and of a design using a composite vessel for boiling water reactors are compared with respect to the effects of water/steam separation and requirements for a secondary vessel and coolant pumping systems. An economic comparison is also made. The principle of the metal-lined prestressed concrete pressure vessel is outlined, and the behavior of the composite vessel is calculated. The components of the composite vessel are described, and the problem of anchoring the metal liner is discussed. The horizontal and vertical effects of the anchoring are reviewed. The advantages of the composite system are outlined, and the research and development program necessary to establish the feasibility of such a system is indicated. (J.S.R.)

**16183** CORROSION PRODUCTS IN THE PRIMARY COOLING CIRCUIT OF PRESSURIZED WATER REACTORS. Winkler, R.; Mittag, I.; Sachse, G. (VEB Kernkraftwerk, Rheinsberg, Ger. Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Kernenergie; 12: 347-51(Nov 1969). (In German).

The concentration, particle size, chemical composition, and specific activity of the corrosion products are analyzed. The research techniques are also described. 4 references. (auth)

**16184** THERMAL INSULATION STRUCTURES AND FAST REACTOR HAVING SUCH INSULATION. Hayden, Owen; Taylor, Derek; Tisdall, Derek Edmund (to United Kingdom Atomic Energy Authority). U. S. Patent 3,488,255. 6 Jan 1970. Priority date 9 Dec 1966, Great Britain.

A thermal insulation structure for direct contact with liquids is built up from several layers of panels, each panel comprising a pair of substantially parallel metal sheets joined directly to each other by welding along lines or ribs which describe a multiplicity of closed shapes within the outlines of the sheets, so as to form a multiplicity of gas-containing compartments which are sealed from one another. The layers are spaced apart to allow liquid to infiltrate between them, circulation of liquid being discouraged, and the compartment defining welds of a layer are staggered relative to an adjacent layer. Constructions applicable to the thermal insulation of a jacket for the core of a sodium-cooled fast nuclear reactor are described. (Offic. Gaz.)

**16185** EXPECTED COOLING FROM A REACTOR COOLANT CIRCUIT. Marshall, F. (United Kingdom Atomic Energy Authority, Risley, Eng.). J. Brit. Nucl. Energy Soc.; 9: 62-71 (Jan 1970).

In a reactor coolant system with no spare capacity, the fewer the circuits adopted in the design, the better the expected availability. The economics of providing spare cooling capacity is considered using an advanced gas-cooled reactor as an example. (auth) (UK)

**16186** PUMP FOR NUCLEAR REACTOR. (to Societe Belge Pour l'Industrie Nucleaire). British Patent 1,178,664. 21 Jan 1970. Priority date 27 Jan 1967, Belgium.

HEAT TRANSFER SYSTEMS—pumps for primary and secondary liquid metal cooled reactor, with rotors mounted on single shaft
PUMPS—design for primary and secondary cooling circuits with rotors mounted on single shaft
REACTORS, LIQUID METAL COOLED—cooling systems for sodium cooled, design of single pumps for primary and secondary (H.D.R.)

**16187** IMPROVEMENTS IN OR RELATING TO ROTARY FLUID CIRCULATORS, e.g. FOR NUCLEAR REACTORS. (to Gulf General Atomic Inc.). British Patent 1,179,097. 28 Jan 1970. Priority date 6 Sep 1966, United States.

BLOWERS—design of cooling system gas, with two independent turbine drive systems
HEAT TRANSFER SYSTEM—blowers for gas cooled reactor, with two independent drive systems
REACTORS, GAS COOLED—coolant circulator for, with two independent turbine drive systems (H.D.R.)

## Fuels

*Refer also to abstracts 13991 and 16309.*

**16188** (ANL-7574) DESIGN PARAMETERS AND PERFORMANCE CHARACTERISTICS OF A MINIATURE PRESSURE-TRANSDUCER SYSTEM USING A FLUID-FILLED BELLOWS SENSOR. Folkrod, John R. (Argonne National Lab., Ill.). Oct 1969. Contract W-31-109-eng-38. 23p. Dep. CFSTI.

Optimal design parameters are developed and two working models are assembled to demonstrate the feasibility of transmitting fission-gas pressures generated in LMFBR-type fuel pins via a miniature, NaK-filled bellows-capillary tube to a strain-gauge transducer located outside the core environment. The key problem is obtaining a voidless fill. Both models were readily assembled, using commercially available components. The first model featured a $\frac{1}{8}$-in.-OD stainless steel bellows welded to a $\frac{1}{8}$-in.-OD, $\frac{1}{16}$-in.-ID stainless steel capillary tube, 24 ft long, which, in turn, was welded to a strain-gauge transducer. After filling with NaK, the transducer system was calibrated and then operated continuously for three months at 1200°F. During this period, the "sensing" end of the bellows was exposed to 120 pressure cycles (0—100 psig) without malfunction. Comparison of transducer outputs with precision-gauge readouts on the pressurizing chamber indicated a system accuracy of $\pm\frac{1}{2}\%$ and a time response of 1 sec. The second model was an attempt toward the ideal system. For immediate purposes, a nickel bellows of $\frac{1}{8}$-in. OD was procured and similarly interconnected with a 0.020-in.-ID stainless steel capillary tube. Several cleaning and filling procedures were required before the slightest compression of the bellows resulted in essentially full deflection of the transducer diaphragm, indicative of a voidless fill. Bellows failure due to nickel embrittlement precluded system calibration. It is concluded that, with improvements in filling techniques, a commercially available stainless steel bellows of 0.220-in. OD coupled to a capillary tube of 0.012-in. ID would satisfy criteria established for LMFBR fission-gas pressure sensors. (auth)

**16189** (ANL/EBR-7) CORE-LOADING DIAGRAMS FOR EBR-II RUNS 4 THROUGH 38, APRIL 1965–MID-DECEMBER 1969. Case, J. C. (comp.) (Argonne National Lab., Ill. Argonne National Lab., Idaho Falls, Idaho). Dec 1969. Contract W-31-109-eng-38. 145p. Dep. CFSTI.

Core-loading diagrams are shown for all EBR-II Run Nos. 4 through 38. Total accumulated run time through this time period was 28,760 MWd. Accompanying each core diagram are physical descriptions, location of experimental subassemblies, and legends for the diagrams. (M.L.S.)

**16190** (GEAP-10028-32) SODIUM-COOLED REACTORS. FAST CERAMIC REACTOR DEVELOPMENT PROGRAM. Thirty-Second Quarterly Report, August–October 1969. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Nov 1969. Contract AT(04-3)-189. 97p. Dep. CFSTI.

FAST CERAMIC REACTOR—fuel elements for, development during Aug. to Oct. 1969
—core for, design and kinetics analyses of
—safety of, transient overpower and loss of coolant flow effects on
INCOLOY 800—radiation effects on fast reactor fuel element cladding of
PLUTONIUM OXIDES $PuO_2$—$PuO_2$–$UO_2$, radiation testing of fuels of
—$PuO_2$–$UO_2$, physical properties of fuels of
REACTOR FUEL ELEMENTS—development of high performance mixed oxide, for Fast Ceramic Reactor
—cladding for mixed oxide, performance of defected
—cladding interface performance in contact with liquid sodium
—fission product distribution and release rate from mixed oxide
—cladding alloys for mixed oxide fast, performance of
REACTOR FUELS—performance of mixed oxide fast
REACTOR SAFETY—transient overpower effects of Fast Ceramic Reactor fuel elements
STAINLESS STEELS—radiation effects on fast reactor fuel element cladding of
URANIUM OXIDES $UO_2$—$PuO_2$–$UO_2$, radiation testing of fuels of
—$PuO_2$–$UO_2$, physical properties of fuels of (H.D.R.)

**16191** (HPR-114) POST-IRRADIATION EVALUATION OF THE THIRD SWEDISH FUEL ASSEMBLY, IFA-21, IRRADIATED IN THE HALDEN BOILING HEAVY WATER REACTOR. Djurle, S.; Taylor, H. (Institutt for Atomenergi, Halden (Norway). OECD Halden Reaktor Prosjekt). Nov 1969. 42p. Dep. CFSTI (U. S. Sales Only).

Detailed post-irradiation examinations were performed on the five fuel rods of IFA-21 (S), irradiated in the Halden Boiling Heavy Water Reactor (HBWR) to a mean value of about 9650 MWd/tU. The fuel rods consisted of Zircaloy-2 cladding containing sintered $UO_2$ pellets enriched to 5 wt % U-235 of total uranium. Crack failures in four of the five rods are attributed to excessive plastic strains in the cladding; mode of reactor operation may have been a contributing factor to the failures. 8 references. (auth)

**16192** VARIATIONS IN THE COST OF THE FUEL CYCLE WITH LOCAL CONDITIONS. Scuricini, G. B.; Calori, F. (Comitato Nazionale per l'Energia Nucleare, Rome). pp 215-36 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968). (In French).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

The cost of the fuel cycle, although much less subject to the effect of local factors than the capital cost of the station, nevertheless depends fairly closely on the development of nuclear programs as a whole. Variations in fuel-cycle costs are discussed: the cost of the natural and enriched uranium, the fabrication and reprocessing costs, and the costs of transport of the raw and irradiated fuel. These variations depend on the capacity of the reprocessing plants and on changes in the material supply situation. The effect of the variations in these costs on the cost of the fuel cycle are considered. The method chosen for the evaluation of the cost of the fuel cycle is based on discount and is especially adapted to the use of electronic desk calculators. 20 references. (auth)

**16193** INFLUENCE OF THE ECONOMIC SCALE ON NUCLEAR FUEL CYCLES. Thiriet, L.; Massetti, C. (CEN, Fontenay-aux-Roses, France). pp 237-49 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968). (In French).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

The industrial installations for fuel processing are very sensitive to the scale effect; in other words the total yield from the capital invested increases fairly rapidly with plant size, but may be reduced by technical limitations such as reduction of the load factor in multipurpose plants or over-dimensioning in anticipation of demand. The influence of the scale effect on the cost of fuel cycles for various types of reactor are shown. A method of analyzing the scale effect in accordance with the various fuel cycle cost components and arrive at certain conclusions is described: the effect of size on fuel cycle costs is considered for natural uranium and of enriched uranium reactors. The proportional cost for fast reactors will be very small and the programme effect will reduce out-of-pile stocks of plutonium. (auth)

**16194** NUCLEAR FUEL COST CALCULATIONS. Zizza, M.; Davis, Joyce P. (Burns and Roe, Inc., Hempstead, N. Y.). pp 251-67 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Digital computer programmes prepared for calculation of nuclear fuel costs are described. The cost calculations, in general, follow procedures outlined in Guide to Nuclear Power Cost Evaluation, Volume 4, Fuel Cycle Costs, Kaiser Engineers Report TID-7025, 15 March 1962. NUFUCO I determines overall core fuel costs. The programme has facility for calculating a weighted average capacity factor to be used in the core cost calculations. All fuel is treated as being reprocessed in one batch. The programme also is capable of handling the possibility of a throw-away cycle and will calculate the cost for such a cycle if it is more economic than the reprocessing-plutonium credit cycle. The programme output gives the total cost for uranium burn-up as one value and separates the interest into two components: Use Charge and Interest During Fabrication. This programme is particularly appropriate for determining fuel costs under USAEC-leased conditions. NUFUCO II determines time patterns for expenditures based on batch-by-batch fuel-cost calculations. Although the programme calculates use charge, this may not be directly used in the expenditure pattern time sequence. This use charge includes both interest on uranium inventory and charges due to the deferral and credit for plutonium that occur when fuel batches are accumulated for reprocessing in larger batches. This programme can calculate the optimum number of identical batches to minimize overall fuel-cycle costs. This calculation is optional and single-batch reprocessing costs can also be calculated. The output presents uranium fuel cost and credit separately for application to an expenditure pattern. NFNP is a nuclear fuel management programme which calculates the cost and credit items in the nuclear fuel cycle, the present worth of all expenditures and credits for fuel over the nuclear power plant lifetime, and the average value of energy necessary to recover all investments for fuel. Results of applying the nuclear fuel cost programmes are presented. (auth)

**16195** EVALUATION OF NUCLEAR FUEL CYCLE COSTS. Macklin, L. (United Nuclear Corp., Elmsford, N. Y.). pp 269-77 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Published data for nuclear fuel costs can be misleading unless one has sufficient insight into the effects of variations in the several components of such costs. This insight is of importance when evaluating fuel costs emanating from different economic ground-rules. It is of even greater importance when a reactor is purchased abroad with the intent of the importing utility to utilize domestic sources for fabrication of fuel beyond the initial core. Using typical, large (500–1000 MW(e) net), light-water power reactors as examples, the step-by-step processes that a fuel supplier utilizes in arriving at his proposed fuel-cycle costs are presented. The elements of uncertainty and risk which can have significant cost effects are examined. The procedure utilized by the electric utility in evaluating the inputs from the fuel supplier and the effects of the various assumptions on utility economics are presented. Factors which influence purchase of fully guaranteed all-energy contracts versus component-by-component procurement are outlined. Conditions under which the different modes of procurement should be considered are related to the basic requirements of various classes of utilities. The effects of introducing fuel supplied by a manufacturer other than the original reactor supplier are reviewed from the technical, warranty and economic points of view. (auth)

**16196** THE INTERNATIONAL EXTRAPOLATION OF BRITISH NUCLEAR FUEL CYCLE COSTS. Shallcross, J. E. (United Kingdom Atomic Energy Authority, Warrington, Eng.). pp 279-99 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

The two methods of fuel cycle costing employed in the United

Kingdom are discussed in some detail. The first method is used when a complete assessment of all necessary fuel cycle parameters has been carried out and when absolute values are required for cost comparison. The second method is used when a minimum of reactor data is available and enables quick but less accurate comparisons to be made. The conditions or ground rules which may have to be altered as part of the extrapolation are described. The effect of various parameters on fuel cycle cost will be quantified as far as UK-designed reactors are concerned. An attempt will also be made to show the effect of each item on the fuel cycle costs of national designs of reactors supplied by other countries such as the boiling water reactor and the CANDU reactor. (auth)

16197 THE ADAPTABILITY OF THE HTGR TO VARIOUS NATIONAL REQUIREMENTS. Fischer, P. U.; Jaye, S.; Stewart, H. B. (Gulf General Atomic, Inc., San Diego, Calif.). pp 301-11 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Since economic conditions vary considerably among the nations, the reactor's fuel cycle should be optimized to accommodate each specific situation. This puts a premium on a reactor type, such as the HTGR, in which fuel and fuel cycles are sufficiently flexible to accommodate the various national requirements. This flexibility is the result of using an all ceramic fuel element with no paracidic neutron absorbing structural material in the core. For the economic conditions generally applicable in the USA the HTGR uses Th as the fertile material with $^{233}U$ recycle and $^{235}U$ for any required fissile make-up. Studies of alternate fuel cycles indicate that the $^{235}U$ make-up can be replaced by Pu discharge from a low enrichment thermal reactor without losing very much of the fuel-cycle-cost advantage of the HTGR. With Pu being produced as a by-product in first generation reactors throughout the world, this mode of operation may afford a means for markedly reducing the foreign exchange requirement of a nation's nuclear power system. Another alternative fuel cycle is the use of low-enrichment U in the HTGR while retaining the general characteristics of the fuel. It appears the HTGR could operate with a large variety of fuel cycles without major changes in either the fuel element design or the reactor plant. This gives the operator a considerable degree of flexibility and will allow meeting the particular requirements of a nation in which the reactor is built. (auth)

16198 FISSION PRODUCT DECAY HEAT. Crum, Richard J. (Lewis Research Center, Sandusky, Ohio). Nucl. Appl., 6: 102-3(Feb. 1969).

Decay heat values are presented as a function of time at power and decay time. Graphs are included. (D.C.C.)

16199 LAYOUT AND ARRANGEMENT OF A REACTOR CHARGING INSTALLATION BASED ON RELIABILITY CONSIDERATIONS. Hennings, Uwe (Brown Boveri/Krupp Reaktorbau GmbH, Mannheim, Ger.). At. Strom; 15: 217-24(Dec 1969). (In German).

The charging installation under investigation is treated as a combined system composed of different parts (drives, seals, pipes, valves, controls etc.) the behavior of which is known or for which the reliability figures are given, and which can be checked by individual tests. 6 references. (auth)

16200 FUEL ELEMENT DEVELOPMENT. Falcinelli, Gianfranco. Com. Naz. Energ. Nucl., Notiz.; 14: No. 8-9, 83-108(Aug-Sep 1968). (In Italian).

Fast reactor fuel element development is discussed in some detail. Flow sheets and tables show characteristic parameters and developmental processes for vented fuel elements. Results of in-pile and out-of-pile and mechanical-hydraulic testing are summarized. Fuel-irradiation-testing environments in PEC, EFFBR, EBR-2, DFR, and Rapsodie are outlined. The Italian program for fuel testing is described. Post-irradiation examination is discussed. (M.L.S.)

16201 INTERNAL GAS ADSORPTION MEANS FOR NUCLEAR FUEL ELEMENT. (to Westinghouse Electric Corp.). British Patent 1,181,960. 18 Feb 1970. Priority date 2 Feb 1968, United States.

CARBON (SURFACE-ACTIVE)—use in pressurized water reactor fuel elements for monatomic gas adsorption
REACTOR FUEL ELEMENTS—gas adsorption in pressurized water, description of activated charcoal chamber for monatomic
REACTORS, PRESSURIZED-WATER—fuel element of, description of monatomic gas adsorption chambers of activated charcoal for cylinder shaped (D.C.C.)

16202 MANUFACTURE OF ZIRCONIUM ALLOY TUBES FOR HEAVY-WATER MODERATED REACTORS. Chrimes, N. W. D. (Australian Atomic Energy Commission Research Establishment. Lucas Heights). At. Energy Aust. 12: No. 4, 9-12(Oct 1969).

A considerable amount of Zr alloy tubing is required for heavy-water moderated reactors of the Canadian Deuterium Uranium (CANDU) type, which contain coolant and nuclear fuel in channels (calandria tubes) which pass through the moderator. The approximate sizes, material and general requirements of the calandria tubes, as well as the pressure and fuel tubes, are tabulated. The seamless and welded methods of tube manufacture are compared, and it is concluded that welded tubing has the following advantages over seamless tubing— more uniform wall thickness; better bore surface condition; lower cost. For pressure tubes, only seamless welding is considered, because of the more arduous service conditions. (Australia)

16203 HOMOGENEOUS, THERMAL NUCLEAR FISSION REACTOR. Mialki, Werner; Wille, Rudolf. U. S. Patent 3,494,829. 10 Feb 1970. Priority date 13 Jan 1962, Germany.

In a homogeneous, thermal nuclear fission reactor there is provided a diathermanous solution of a fissionable material and a moderator substance in a molten oxyceramic composition which forms a glass when congealed or a molten mixture of metal oxides. This permits the reactor to operate at temperatures in excess of 1000°C. (Offic. Gaz.)

## Auxiliary and Emergency Systems

*Refer also to abstracts 14203 and 14809.*

## Operation and Economics

16204 (JUL-590-RG) SYSTEM INVESTIGATIONS ON THE LONG-TERM ECONOMIC OPERATIONAL POSSIBILITIES OF DIFFERENT TYPES OF POWER PLANTS WITH SPECIAL REGARD FOR THE THORIUM HIGH TEMPERATURE REACTOR. Wagemann, Klaus (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorentwicklung). Feb. 1969. 129p. (In German). Dep. CFSTI (U. S. Sales Only).

Thesis. Submitted to Technische Hochschule, Aachen, Ger.

The long term operational reactor concepts of interest to the German Federal Republic are analyzed. A computer program is used to simulate the complex networks in an electrical distribution system. The length of operation of the power is determined in the computer model so that, for a given time, a minimum electrical generating cost can be calculated. The most important transmission lines are investigated in various combinations. For the analysis, the required fuel cycle capacities are considered in combination with electrical production costs. Cost data analyses and the various fuel and turbine combinations are compared for the HTR and fast breeder concepts. These cost calculations and data analyses will change as a function time and are dependent on the state-of-the-art. (M.L.S.)

16205 (SGAE-RT-22/1969) AVERAGE FUEL CYCLE COST OF NUCLEAR ENERGY PLANTS AT DIFFERENT LOAD FACTORS. Gruemm, H.; Nathschlaeger, P. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Seibersdorf). 1969. 13p. (In German). (CONF-690419-1). Dep.

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

The effect of the transient load factors of nuclear energy plants on the fuel cycle costs was studied using three typical transient models. The calculations showed that the effect of the load factor distribution on the fuel cycle costs remain within describable limits. The effect can be reduced by a suitable fuel loading program. (J.S.R.)

16206 OPERATING FLEXIBILITY THROUGH IN-CORE FUEL MANAGEMENT. Grube, R. M. (Yankee Atomic Electric Co., Boston); Hinkle, W. D.; Cahn, H.; Knapp, R. W. Combustion; 41: No. 4, 13-17(Oct 1969).

The trade-off between the power capability and the length of the various operating cycles of a pressurized-water reactor is examined from the standpoint of power cost and power capability in subsequent cycles. The example of operating flexibility presented is intended to represent a late change in the refueling date rather than a planned extension of core life. Power cost comparisons are presented for two variations from a basic fuel management scheme. (H.D.R.)

16207 LIMITATIONS OF GENERALIZED NUCLEAR POWER COST COMPARISONS. Stadie, K. B. (European Nuclear Energy Agency, Paris). pp 3-21 of International Comparison of

Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

The wide disparity of the major economic criteria—capital charge and load factor—and their strong local dependence prevent the use of common criteria for the economic assessment of specific nuclear projects and limit the usefulness of more general economic evaluations. The impact of the economic criteria on the optimization of generating stations, the effect of wide variations in site-adaptive costs, licensing procedures, design and manufacturing codes on plant costs, and the inadequacy of international cost comparisons based on the official exchange rate, hinder a direct comparison of generating costs. Furthermore, the considerable number of cost parameters influencing the choice and cost of the fuel cycle for a reactor system are also affected by local conditions and, therefore, add to the uncertainty of generalized nuclear power cost comparisons. Combination of these possible variations can lead to a spread of generating costs which tells very little of the true economic potential of one over another reactor system. 25 references. (auth)

**16208** SENSITIVITY OF THE COST PER kWh OF NUCLEAR POWER TO THE VARIATION OF CERTAIN PARAMETERS. Leo, B. (Electricite de France, Paris). pp 23-39 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968). (In French).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

Economic calculations to determine the cost per kWh of nuclear power involve a large number of parameters of a financial, economic and technical nature. The calculation of this cost requires the assignment of a value to each of the parameters entering into the calculation. This evaluation, called reference value, is subjective and furthermore changes with time. For certain parameters the values considered result from known data which can, however, vary from one country to another; others involve choice between various possibilities; and still others depend on an assessment which is arbitrary but regarded as probable in the light of the information available. It is, therefore, very difficult, or indeed impossible, to make a rapid comparison between two kWh costs determined with reference to different basic hypotheses and at different times, since it is necessary to return to these basic hypotheses and repeat the calculations for one of the costs and sometimes for both. Furthermore, the effect of the various parameters on the final result is naturally greater or smaller according to the nature of the parameters themselves; some may be regarded as fundamental (rate of discount or interest; annual utilization of the station and its availability; lifetime of the station; specific investments; cost of the fuel cycle) and others as secondary. The sensitivity of the cost per kWh to the fluctuation of the different parameters about a value representing a basic hypothesis is analyzed. Since the results are presented graphically, it is possible to make rapid comparisons, and the effect of the modification of a basic hypothesis on the cost per kWh can be immediately read off. Though the method is not very precise, it provides a means of rapid estimation of orders of magnitude. (auth)

**16209** PROBLEMS ASSOCIATED WITH THE INTEGRATION OF DIFFERENT TYPES OF REACTOR WITHIN A GENERATING SYSTEM. Iliffe, C. E.; Searby, P. J. (United Kingdom Atomic Energy Authority, Warrington, Eng.). pp 99-110 of International Comparison of Nuclear Power Costs. Vienna; International Atomic Energy Agency (1968).

From Symposium on International Extrapolation and Comparison of Nuclear Power Costs, London, England. See STI/PUB-164; CONF-671089.

On present estimates it will be economical to meet the greater part of the increase in electricity demand after 1975 by nuclear capacity. The different reactor types will interact with one another, particularly as regards load factor and plutonium supply and demand. Any attempt to forecast the composition of the generating system from 1975 onwards must therefore take these interactions into account. The forecast must also allow for constraints, such as the natural caution of electricity-producing authorities in introducing a new type of reactor. The method which has been adopted in the UKAEA to construct models of integrated reactor systems for the assessment of the benefits attainable from different installation programmes are described. The method can accommodate wide variations in assumptions. The criterion of economic merit is the present worth of expenditure on the whole nuclear generating system or a part of it. Alternatively, this expenditure may be divided by the present worth of electricity generated by the system to give an average, or system generating cost. The result is independent of plutonium price but such prices can be found for any plutonium transferred into or out of the system. 4 references. (auth)

## *Safety and Siting*

*Refer also to abstract 13803.*

**16210** (AED-C-1-17(1969)) BIBLIOGRAPHIES IN NUCLEAR SCIENCE AND TECHNOLOGY. CIVIL ENGINEERING. NO. 17. REACTOR SAFETY ENCLOSURE. (Zentralstelle fuer Atomkernenergie-Dokumentation, Frankfurt am Main (West Germany)). Aug 1969. 125p. (In German). Dep. CFSTI (U. S. Sales Only).

A bibliography covering the 1957–1968 information on reactor safety is presented. Abstracts (in German), author indexes, publisher indexes, report indexes, and subject indexes are included. 120 references. (M.L.S.)

**16211** (BMI-1877) AN EVALUATION OF THE APPLICABILITY OF EXISTING DATA TO THE ANALYTICAL DESCRIPTION OF A NUCLEAR-REACTOR ACCIDENT. Quarterly Progress Report, October–December 1969. Carbiener, Wayne A.; Ritzman, Robert L. (Battelle Memorial Inst., Columbus, Ohio). Jan 1970. Contract W-7405-eng-92. 34p. Dep. CFSTI.

REACTOR FUEL ELEMENTS—cladding for, effects of coolant loss accidents on swelling of
REACTOR SAFETY—coolant loss accidents in water cooled reactors, analytical description of
REACTORS, BOILING—coolant loss accidents in, evaluation of data for analytical description of
—kinetics equations for, modifications in ADEP code for spatial
—fuel element cladding for, effects of coolant loss on swelling of
—emergency core cooling system performance during coolant loss accidents, thermal hydraulic computer code for
REACTORS, PRESSURIZED WATER—coolant loss accidents in, evaluation of data for analytical description of
—kinetics equations for, modifications in ADEP code for spatial
—fuel element cladding for, effects of coolant loss on swelling of
—emergency core cooling system performance during coolant loss accidents, thermal hydraulic computer code for
(H.D.R)

**16212** (BNL-14278) A REVIEW OF THE CURRENT STATUS OF RESEARCH ON THE CHEMICAL AND PHYSICAL ASPECTS OF LIQUID-METAL-COOLED FAST BREEDER REACTOR SAFETY. I. FISSION PRODUCT BEHAVIOR IN SODIUM. Castleman, A. W. Jr. (Brookhaven National Lab., Upton, N. Y.). [1969]. 41p. Dep. CFSTI.

The current status of research on the chemical and physical aspects of liquid-metal-cooled fast breeder reactor safety is reviewed. Present knowledge on the behavior of fission products comprising the noble gases, halogens, alkali metals, alkaline earth metals, and rare earths, in Na systems is summarized. Considerable information is available on their behavior in the event of minor accidents in which deposition within the reactor primary system and vaporization to the cover-gas would be of concern to the reactor operator. Data on the factors controlling their chemical states and rates of vaporization are discussed. The thermodynamic data available for many of the fission product-sodium systems are shown to be useful in estimating fission product partial pressures above liquid sodium and the maximum extent of vaporization under conditions such that sodium vaporization is significant. 31 references. (auth)

**16213** (BNWL-1166) ASPRIN: A COMPUTER CODE FOR PREDICTING REACTOR VESSEL RESPONSE TO HYPOTHETICAL MAXIMUM ACCIDENTS ON FAST REACTORS. Fox, G. L. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Dec 1969. Contract AT(45-1)-1830. 79p. Dep. CFSTI.

Current nuclear reactor design procedure postulates a maximum reactor excursion in order to test containment. The maximum cover loadings are assumed to result from a coolant slug propelled against the cover by blast pressure in the core region. A method for predicting these head loadings is described. The analytical method utilizes combinations of 1 dimensional Newtonian models in radial and axial directions to simulate the reactor, cover, and holddown structure. Wave phenomena are not considered and deformations are assumed to occur from quasi-steady pressures. The equations have been programmed and output information consists of gross vessel and cover displacements, velocities, stresses, strains, and the blast energy dis-

tribution. A sample problem is included which demonstrates the effect of vessel parameters on the cover loading problem. (auth)

16214 (BNWL-SA-2746) DISSOLVED GAS INFLUENCE ON A PWR DESIGN BASIS DECOMPRESSION. Allemann, R. T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 16p. (CONF-691102-13). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

The facility and procedures used in a series of design basis piping rupture accident simulations are described. Blowdown test simulation for a pressurized water reactor showed slower rates of decompression than anticipated. The cause of this phenomenon was determined to be related to nitrogen gas dissolved in the water from the nitrogen gas pressurizer system used with the test vessel. Additional test runs were made both with and without nitrogen, and decompression forces were measured. The potential use of this dissolved gas phenomenon to reduce the loads on the reactor core and other internal parts during coolant loss accidents is discussed. (H.D.R.)

16215 (CEA-CONF-1435) BEHAVIOR OF FISSION PRODUCTS OBSERVED IN THE COURSE OF OPERATION OF C.E.N., SACLAY, REACTORS. Lebouleux, Ph.; Petitcolas, H. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [nd]. 15p. (In French). (CONF-691104-3). Dep. CFSTI (U. S. Sales Only).

From International Congress on the Diffusion of Fission Products, Saclay, France.

A description of fission product behavior in the EL-3, OSIRIS, and ISIS reactors subsequent to fuel element rupture is given. The fuel rupture incident in the EL-3 is described; the fission product release into the cooling water, and, subsequently into the air is discussed. Fission product activities and curie-amounts are tabulated for the time span of 3 months, 6 months, and 1 year following the rupture. Similar discussions, descriptions, and data are included for the ISIS and OSIRIS incidents. (9 references) (M.L.S.)

16216 (KFK-1044) FAUN-Z: CALCULATIONS OF SEVERE REACTOR ACCIDENTS ACCORDING TO THE MODIFIED BETHE-TAIT METHOD IN r, z GEOMETRY. Thurnay, K. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Neutronenphysik und Reaktortechnik). Apr 1969. 52p. (In German). (EUR-4310). Dep. CFSTI (U. S. Sales Only).

For the IBM 7074 computer, a program is developed that allows calculation of severe excursions in a cylindrical two-zone reactor core. The program is based on the modified Bethe-Tait method. The underlying mathematics is described in detail. Actual computer programs are listed and results are tabulated. (H.B.G.)

16217 (ORNL-4400, pp 118-26) NUCLEAR SAFETY TESTS IN MAJOR FACILITIES. (Oak Ridge National Lab., Tenn.).

Topics covered include: aging behavior of fission products released by in-pile melting of $UO_2$, in-pile behavior of HTGR fuel elements in mixtures of steam and helium, TREAT fuel rod failure loss-of-coolant experiment, prompt clad failure release of fission products from reactor fuel elements (out of pile), and effect of emergency core coolant on fission product prompt failure release and containment behavior. (M.C.G.)

16218 (ORNL-4400, pp 127-33) AEROSOL BEHAVIOR. (Oak Ridge National Lab., Tenn.).

Topics covered include: fission product deposition characteristics in thermal gradient tubes, filtration of aerosols, behavior of aerosols in a reactor containment vessel, and effect of aerosol mass concentration on the natural removal rate in a reactor containment vessel. (M.C.G.)

16219 (ORNL-NSIC-72) INDEXED BIBLIOGRAPHY OF CURRENT NUCLEAR SAFETY LITERATURE-23. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 361p. Dep. CFSTI.

Publications in the field of nuclear safety that were processed at the NSIC during July and August 1969 are cited. Developments relevant to the analysis and control of hazards associated with nuclear reactors, operations involving fissionable materials, and the products of nuclear fission are included. The citations are sorted into 18 categories, and author and keyword indexes are provided. (H.D.R.)

16220 (SGAE-RT-23/1969) LIBERATION OF GASEOUS ACTIVITY BY NUCLEAR POWER PLANTS. Hoertner, H. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Seibersdorf. Institut fuer Reaktortechnik). [1969]. 16p. (In German). Dep. CFSTI (U. S. Sales Only).

The origin and type of gaseous activities occurring by air activation and in the coolants of water-cooled, $CO_2$-cooled, and He-cooled reactors were outlined. The activation of the coolant by radioactive corrosion products and by fission products occurring in the coolant was considered. The release of the gaseous activities was compared for various reactor types. The propagation of the gaseous activities in the atmosphere is considered. (J.S.R.)

16221 (UJV-2277-R,P,A) IN-LINE DIGITAL COMPUTERS FOR A REACTOR SAFETY SYSTEM? Kovanic, P.; Rygl, J. (Ceskoslovaneska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu). Oct 1969. 17p. (CONF-691115-3) Dep. CFSTI (U.S. Sales Only).

From Symposium on the Performance of Nuclear Power Reactor Components, Prague, Czechoslovakia.

The requirement to minimize the less of availability of a power reactor due to false alarm of a reactor safety system is contradictory relating to the requirement of minimum hazard of missing an actual emergency case. The choice of a compromise is complicated because of the fact that to raise the efficiency one chooses nominal parameters close to their emergency limits. Under such conditions, highly sophisticated formulation of the tasks of a safety system can be economically justified; the treatment of signals from the reactor approaching the procedures of testing statistical hypotheses on the reactor state. Such complicated functions can not be carried out by an apparatus of analog type. On the other hand, the experience of designing special-purpose computers for reactor control and safety systems has shown that such digital devices will not be competitive with general-purpose computers unless the number and complexness of different functions exceed certain relatively low limits. The meet all requirements shown above together with the requirement of reliability and autonomy of the reactor safety system, one could design them as a family of, e.g., three independent small-size general-purpose on-line computers. Statistical formulation of data processing problems for reactor safety systems as well as one possible approach to the effective solution of this problem based on the method of static programming are given. (auth)

16222 CONTAINMENT ARRANGEMENT FOR WATER COOLED NUCLEAR REACTOR INSTALLATION. Davey, Wesley Pearce; Burnup, Thomas Elliott (to United Kingdom Atomic Energy Authority). U. S. Patent 3,488,254. 6 Jan 1970. Priority date 28 Apr 1966, Great Britian.

In a reactor with a pressure suppression device, a baffle limits the flow into the pressure suppression device so that excess flow is directed through an over-pressure-blow-off valve set to a higher pressure than is needed for the pressure suppression device. In a water tube reactor, the baffle divides the primary containment so that any faults in the core which are limited in size by the construction of the core are vented directly through the pressure suppression device but so that faults in other places likely to cause excess flow are separated by the baffle from the pressure suppression device and are vented directly to atmosphere through said valve. Any radioactive pollution occurs in small flows so that excess flows can be safely discharged. (Offic. Gaz.)

16223 SAFETY COOLING SYSTEM FOR A NUCLEAR REACTOR. (to Westinghouse Electric Corp.). British Patent 1,178,380. 21 Jan 1970. Priority date 28 Sep 1967, United States.

HEAT TRANSFER SYSTEMS—design of water cooled reactor pressurized emergency core
REACTOR SAFETY—emergency core cooling system for water cooled reactors, design of pressurized
REACTORS, WATER-COOLED—coolant loss accidents in, pressurized emergency core cooling system design for
(H.D.R.)

16224 NUCLEAR SAFETY. VOLUME 11, NUMBER 2. Cottrell, William B.; Jordan, W. H.; Blakely, J. P.; Savolainen, A. W. (eds.). One of Four Technical Progress Reviews Published for the Division of Technical Information, USAEC. Oak Ridge, Tenn.; Oak Ridge National Lab. (Mar-Apr 1970). 79p. GPO $0.60.

Eight sections on material related to nuclear safety are included. A separate abstract was prepared for each section. (R.C.K.)

*For abstracts of individual sections see: 14236, 16110–16114, 16225, and 16251.*

16225 PROGRESS SUMMARY OF NUCLEAR SAFETY RESEARCH AND DEVELOPMENT PROJECTS. Savolainen, A. W.; Whetsel, H. B. Nucl. Safety; 11: 155-71(Mar-Apr 1970).

Summaries of projects sponsored by the Division of Reactor Development and Technology of the U. S. Atomic Energy Commis-

sion are presented. The projects reported deal with water reactor safety, environmental and effluent control studies; general safety studies, fast reactor safety, and gas-cooled reactor safety. (H.D.R.)

### Power Conversion Systems

**16226** DEVELOPMENT OF COMPONENTS FOR SODIUM PLANTS. Tarantini, Arcangelo. Com. Naz. Energ. Nucl., Notiz.; 14: No. 8-9, 109-49(Aug-Sep 1968). (In Italian).

The CNEN program for the development of sodium cooled reactor cooling system components is discussed. The use of scale models for component development is described. Effects of integrated, semi-integrated, and separated coolant circuits are evaluated. Parameter and functional optimization for heat exchangers is discussed; some data are shown graphically. Parameters for steam generators and turbines are tabulated also. (M.L.S.)

**16227** INVESTIGATIONS ON STEAM GENERATORS FOR GAS COOLED POWER REACTORS. Groehn, H. G.; Heinecke, E.; Scholz, F. (Kernforschungsanlage, Juelich, Ger.). Atomwirt., Atomtech.; 14: 581-3(Dec 1969). (In German).

At the KFA Juelich, equipment was built to study heat and hydrodynamic problems occurring in heat exchangers, especially in those producing steam from gas-cooled power reactors. Numerous heat exchange models were constructed. On each of them both heat transfer and hydrodynamic resistance in the range of Reynolds numbers from $10^4$ to $10^6$ were studied on bundles of tubes. In systematic experimental series, conditions for hydrodynamically induced oscillations in the heat exchanger were analyzed. (H.B.G.)

**16228** SECOND SCIENTIFIC CONFERENCE ON STEAM TURBINES OF GREAT OUTPUT, DANZIG, SEPTEMBER 25–28, 1967. Pr. Inst. Masz. Przeply.; No. 42–44, 1-636(1969). (In several languages). (CONF-670994).

A separate abstract is included for one of the 33 papers presented. (D.C.C.)

*For an abstract of one paper see: 16229.*

**16229** COMPARISON BETWEEN STEAM AND HELIUM TURBINES FOR NUCLEAR POWER PLANTS. Bammert, Karl (Technische Univ., Hanover). Pr. Inst. Masz. Przeply.; No. 42–44, 141-65(1969). (In German).

From 2nd Scientific Conference on Steam Turbines of Great Output, Danzig, Poland. See CONF-670994.

The helium turbine is compared with the conventional steam turbine as used in a two-cycle system- with high-temperature reactors. It shows that the sizes and power/weight ratio of helium power plants are less than those of nuclear fired steam turbine power plants. In addition to that, the net efficiency of a helium power plant lies above the nuclear fired steam turbine power plant. Already at gas temperatures of 800°C, for which there are now suitable materials available, net efficiency of 50% can be achieved with a 1000-MW(e) helium power plant. Despite these high figures the helium turbine still has a development potential inasmuch as a further increase of the temperature of the working medium is possible and at the same time, other than with steam turbines, relatively low pressures can be adopted. In the case of high unit capacities (ca. 2000 MW(e)), the combined helium-steam power plant, which receives the advantages of both the turbines and offers favourable efficiency over normal steam and helium power plants, can be recommended. 12 references. (auth)

## Research and Test Reactors

*Refer also to abstracts 14246, 14286, 14364, 14962, 14963, 14973, 14974, 16108, 16124, 16304, and 16317.*

**16230** (BARC-421) ANALYSIS OF ZERO POWER REACTOR III ASSEMBLY 48 WITH RECENT CROSS-SECTION DATA. Mahalingam, L. M.; Singh, R. Shankar (Bhabha Atomic Research Centre, Bombay (India)). 1969. 9p. Dep. CFSTI (U. S. Sales Only).

An analysis of the experimental results of the fast critical assembly 48 of ZPR-III which is a plutonium fueled, soft spectrum and simple geometry system is carried out using a 22-group cross-section set. Computed parameters such as critical mass, spectral indices, reactivity worths of various samples and Doppler coefficients are compared with the experimental values. The effects of using recently evaluated fission cross-sections by Davey and higher $\alpha$ values of $^{239}$Pu measured in the U.K. on the calculated values of these parameters are considered. 6 references. (auth)

**16231** (BNWL-500(Vol.32)) FAST FLUX TEST FACILITY. CONCEPTUAL COMPONENT DESIGN DESCRIPTION FOR THE REACTOR VESSEL AND SHIELD COMPONENT NO. 32. Schively, D. P. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). 24 Apr 1969. Contract AT(45-1)-1830. 107p. Dep. CFSTI.

Design parameters for the FTR reactor vessel and shielding are presented. Safety, operational, and maintenance requirements are described. Problems related to the design requirements of the reactor vessel and shielding are analyzed. (30 references) (D.C.C.)

**16232** (BNWL-500(Vol.35)) CONCEPTUAL COMPONENT DESIGN DESCRIPTION FOR THE FIRST CORE FUEL ASSEMBLY COMPONENT NO. 35. Fast Flux Test Facility. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). 8 Aug 1969. Contract AT(45-1)-1830. 66p. Dep. CFSTI.

Specific design requirements are presented for the FFTF driver fuel assembly. The fuel pins are Pu-enriched $PuO_2-UO_2$ pellets clad with Type 316 stainless steel, with a design goal of 80,000 MWd/tonne peak burnup. The fuel assembly is designed to operate with a mean core outlet temperature of 900°F with an inlet of 600°F, a pressure drop limit of 120 psi at full flow, and a maximum mean liquid Na velocity limit in the pin bundle region of 30 ft/sec. The fuel assembly is composed of the upper and lower coolant duct extensions and the fuel subassembly. The fuel subassembly is defined as the flow duct region containing the fuel pins. Separate sections discuss: function and design requirements; physical description of the component; safety considerations; principles of operation; and assembly, testing, and maintenance principles. (H.D.R.)

**16233** (BNWL-1023) FAST FLUX TEST FACILITY. PLANT OPERATION AND CONTROL. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). 9 Jan 1969. Contract AT(45-1)-1830. 119p. Dep. CFSTI.

A discussion of plant operation and a concept for control and protection of the FFTF are presented. Plant operations including operation of tests, the reactor, and heat removal systems during startup, steady-state operation, and normal shutdown are described. A concept for plant control including nuclear systems, main heat removal systems, and closed loop heat removal systems is presented. Abnormal and emergency plant control, including a concept for controlled power reduction and plant protection, is discussed. 20 references. (auth)

**16234** (BNWL-1138) ANALYSIS OF FTR PHASE B CRITICAL EXPERIMENTS. PART-1. ZPR-III ASSEMBLY 51. Young, W. R.; Bennett, R. A. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 91p. Dep. CFSTI.

Critical experiments in support of the design of the Fast Flux Test Reactor have been carried out in ZPR-III Assemblies 48, 48A, 51, and 52a, b, c, d, e, and f. The results and analysis of the experiments performed in Assembly 51, are presented. 30 references. (auth)

**16235** (BNWL-1275) FAST FLUX TEST FACILITY. Quarterly Technical Report, September–November 1969. Cabell, C. P. (comp.). (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 182p. Dep. CFSTI.

BORON CARBIDES—compatibility with high temperature liquid sodium
—radiation effects on control rod materials of
FAST FLUX TEST FACILITY—design and development during Sept. to Nov. 1969
FAST TEST REACTOR—design and development during Sept. to Nov. 1969
—fuel duct welding for
—cooling system of, component development for
—instrumentation development for
—core design for, development of conceptual
—in-pile loop development for
—fuels for, irradiation testing of
—structural materials for, irradiation testing of
—fuel cycle technology for
—fuel element cladding for, development of stainless steel
—control rods for, reactivity worth of, (E)
—core distortion from stainless steel swelling in, reactivity effects of, (T)
—shielding evaluation for, (E/T)
—safety systems for, response of, (T)
—coolant flow in, effects of in-core instrumentation on, (T)
IN-PILE LOOPS—design and development for FFTF
NEUTRONS, FAST—effects on swelling of stainless steels

PLUTONIUM OXIDES $PuO_2$—$PuO_2$–$UO_2$, irradiation testing of FTR fuels of
RADIATION—effects on boron carbide c ntrol rod materials
REACTOR CONTROL ELEMENTS—reactivity worth of FTR, (E)
REACTOR FUEL ELEMENTS—radiation testing of FFTF
—cladding for FTR, development of stainless steel
REACTOR FUELS—development of FTR mixed oxide, during Sept. to Nov. 1969
SODIUM—effects of high temperature liquid, on boron carbide control rod materials
STAINLESS STEEL—radiation effects on swelling of Type 304 and Type 316, fast neutron
—creep rates for irradiated and unirradiated Type 304 and Type 316
—tensile properties of irradiated Type 304 and Type 316
—crack growth rate in Type 304, stress level effects on fatigue
—strain rate effects on high temperature strength of Type 304
—development of fuel element cladding of
URANIUM OXIDES $UO_2$—$PuO_2$–$UO_2$, irradiation testing of FTR fuels of (H.D.R.)

**16236** (CEA-N-1140) OSIRIS SAFETY STUDY. THERMAL POWER EXTRACTABLE IN NATURAL CONVECTION. Vernier, Philippe (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Jan 1970. 48p. (In French). Dep. CFSTI (U. S. Sales Only).

The residual thermal power extraction by natural convection in Osiris after primary coolant pump failure is analyzed. The cooling of the reactor fuel channel by natural convection is studied in a reactor small-scale model. The behavior of channels put in the thermal environment created by the reactor core is described. A 2 mm diameter hot channel and a 1 mm diameter channel placed between the vessel and a cold plate are studied. (5 references) (France)

**16237** (CEA-N-1205) REPORT ON "OSIRIS-TYPE CORE" EXPERIMENTS PERFORMED ON THE REACTOR CABRI. Dutraive, Pierre; Tattegrain, Alain (Commissariat a l'Energie Atomique, Cadarache (France). Centre d'Etudes Nucleaires). Oct 1969. 79p. (In French). Dep. CFSTI (U. S. Sales Only).

Theoretical and experimental results of tests performed on the reactor Cabri for the purpose of raising the power of the reactor Osiris are given. The main items are the determination of the highest possible power and the core behavior under accidental stopping of coolant flow. 13 references. (auth) (France)

**16238** (CEA-R-3931) THEORETICAL AND EXPERIMENTAL RESEARCH INTO THE HETEROGENEOUS POISONING OF FISSILE-MATTER SOLUTIONS BY TUBES OR RINGS OF BOROSILICATE GLASS. Barbry, Francis; Bouly, Jean-Claude; Caizergues, Robert; Deilgat, Edouard; Houelle, Michel; Lecorche, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec 1969. 135p. (In French). Dep. CFSTI (U. S. Sales Only).

The experimental results obtained with plutonium nitrate solutions poisoned by borosilicate glass tubes or annuli are presented. The results of calculations carried out by various techniques are compared to experimental results. These techniques have made it possible to calculate the values of the critical concentrations in an infinite medium, and of critical masses and volumes for aqueous solutions of plutonium and uranium poisoned by borosilicate glass rings. (6 references) (auth)

**16239** (EUR-4408) SORA DYNAMICS AND CONTROL SYSTEM STUDIES USING MEAN-VALUE NEUTRON KINETICS EQUATIONS. Arhan, R. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1970. 95p. Dep. CFSTI (U. S. Sales Only).

Dynamics and control studies for the pulsed fast reactor SORA are presented. The studies are based on a set of equations for mean-value neutron kinetics. A simulation of the complete set of equations, including thermal reactivity feedback, is performed. As results, the reactor responses to perturbations of reactivity, inlet coolant temperature and coolant velocity are shown. Control rod malfunctions are investigated; a start-up procedure is proposed. A fast control system is synthesized. 13 references. (auth)

**16240** (KFK-1040) INVESTIGATIONS ON THE ANEX IN GEESTHACHT CONCERNING THE USEFULNESS OF REACTIVITY MEASUREMENT FOR FISSIONABLE MATERIAL FLUX CONTROL. Kuechle, M. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Neutronenphysik Reaktortechnik). Aug 1969. 22p. (In German). Dep. CFSTI (U. S. Sales Only).

As a safeguard for the peaceful use of nuclear energy, inspection of the installation and the bookkeeping is performed routinely. A superior control and prevention of deceptions can be accomplished by direct measurement of the $^{235}U$ content of the fuel elements. For this purpose, the element is inserted into three different positions within the core of a critical assembly. By recording the neutron flux, $^{235}U$ content can be determined within 1% accuracy; deception by altering the cladding material can be detected and exchange of plutonium for $^{235}U$ can be readily recognized. The whole procedure requires approximately one minute. The experimental arrangement is described, and the findings are depicted in six diagrams. (4 references) (H.B.G.)

**16241** (ORNL-TM-2675) OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT, JULY–SEPTEMBER OF 1969. Tabor, W. H.; Hurt III, S. S. (Oak Ridge National Lab., Tenn.). 4 Feb 1970. 42p. Dep. CFSTI.

The ORR operated at an average power level of 30.0 MW for 86.9% of the time during July, August, and September of 1969. Twenty-eight fuel elements were declared spent ($^{235}U$ content decreased below 130 g) during the quarter, while twenty-two new fuel elements were placed in service. The average burnup of the elements declared spent was 48.4%. There were six scheduled shutdowns during the quarter and two unscheduled; however, scheduled downtime accounted for 95.4% of the total. For the first time in ORR operating history, a major shutdown was conducted without lowering the reactor pool water and five experiments were handled. In the No. 1 count rate channel, loss of sensitivity of the fission chamber was quite troublesome. Drain lines at the south reactor demineralizer were changed so that regeneration procedures could be effected without entering the shielded demineralizer cell, should conditions warrant. Piping changes were also made in the drain lines for the pools, making it possible to route water directly to the Intermediate-Level Waste System when cleaning the pools. The reactor mechanical components functioned quite normally, except for the south upper bearing assembly which was replaced because it could not be moved to the operate position. The fuel section of a depleted shim rod was inadvertently cut through while the rod was being sectioned for disposal. Some of the resulting fine particles, containing fuel and old fission products, escaped to the pool. Existing facilities and radioactive waste systems were utilized to remove the major part of the contamination and control procedures instituted to prevent spread of the particles enabled the reactor to continue operation without any special shutdown. The neutron source (antimony-beryllium) was removed from the core without any visible effect on the source level as indicated by the count rate channels. The reactivity changes caused by replacing a partially depleted fuel element in core position C-5 with water, aluminum, and beryllium were measured as –1.71, –1.40, and –0.93% $\Delta k/k$, respectively. (auth)

**16242** (RISO-M-976) MTR-TYPE FUEL ELEMENT MODEL EXPERIMENTS AT REACTOR DR 3. 1. EXPERIMENTAL PROGRAMME AND FACILITY DESCRIPTION. Rasmussen, Ingv. (Danish Atomic Energy Commission, Risoe. Research Establishment). Aug 1969. 30p. Dep. CFSTI (U. S. Sales Only).

Investigations on the performance of subchannels of MTR-type fuel elements operating under high heat load conditions have been carried out during 1966 to 69 at the reactor DR3, Risö. An outline is given of the experimental program, comprising studies on steady state and transient heat transfer, fission product release from fuel failures due to insufficient cooling, and fuel plate and in-core instrumentation performance. The X-57 low-pressure closed-loop experimental facility with $D_2O$ forced circulation is described in detail. The test results are summarized in a subsequent report. 2 references. (Denmark)

**16243** (RT/FI-(69)11) STUDY OF NEUTRON SOURCE EFFECTS ON THE LOW-POWER RITMO REACTOR AND DEVELOPMENT OF A SOURCE-DROP TECHNIQUE FOR REACTIVITY MEASUREMENTS. Pedretti, E. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1969. 169p. Dep. CFSTI (U. S. Sales Only).

The variation of the effective multiplication factor originated by the step insertion of a neutron source into a low-power nuclear reactor (source effect) is explicitly introduced into the usual one-energy group, space-independent kinetic equations with source. Analytic solutions are obtained by the Laplace transforms technique, for constant reactivities and for constant neutron source parameters. The existence of source insertion levels for which transients invert is inferred from the coefficients of the exponentials. Results of calculations performed for neutron sources producing positive and negative source effects, for a reactor in a variety of initial conditions and for many insertion levels, are shown in detail. Methods for the measurement of positive and negative source effects, and for obtaining linear divergences in both cases, are described. Results of measurements, carried out by the RITMO RC-4 Reactor, in which both effects are found, and ex-

perimental verification of inversion levels predicted by theory, are reported. Also referred to are the description of a prismatic tangentograph for the measurement of subtangents, and analysis of the inversion of neutron source effects based on neutron diffusion calculations and the description of a method for determination of negative constant components. The development of the source-drop technique, and use of this technique for rod calibration and measurement of large reactivities are described. Spatial effects on results of source-drop technique measurements are considered. 40 references. (auth)

**16244** TRANSFER FUNCTION AND PERIOD REACTIVITY VALUES FROM ROD DROP DECAY DATA. Pasupathy, C. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 369-75 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The rod drop decay data obtained from NORA experiments are analyzed both numerically and by fitting analytical expressions to it to obtain transfer functions and period reactivity values. The limitation of this method at high frequencies due to finite rod drop times is described. The values obtained from the methods presented are compared with values from delayed neutron data. 2 references. (auth)

**16245** REACTOR PHYSICS CALCULATIONS FOR A HIGH DENSITY FAST CRITICAL ASSEMBLY. Kapil, S. K.; Lee, S. M. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 400-7 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

**16246** ANALYSIS OF ZPR-III FAST CRITICAL ASSEMBLY 48 WITH RECENT CROSS-SECTION DATA. Mahalingam, L. M.; Shankar Singh, R. (Bhabha Atomic Research Centre, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 408-11(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

**16247** A 26 GROUP CROSS-SECTION SET AND THE ANALYSIS OF ZPR VI ASSEMBLY 4 Z. Shukla, V. K.; Garg, S. B. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 412-15(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

**16248** $^{135}$Xe CONCENTRATION IN CYCLICALLY OPERATED NUCLEAR REACTORS. Riley, J. A.; Scobie, J. (Scottish Research Reactor Centre, East Kilbride). J. Brit. Nucl. Energy Soc.; 9: 35-54(Jan 1970).

Consideration is given to the $^{135}$Xe build-up in the core of a nuclear reactor which runs on a repetitive cycle of a "fixed-duration/constant-power" period, followed by a "fixed-duration/zero-power" period. The quantities of interest are the maximum $^{135}$Xe concentration occurring during the nth reactor power period and the value of n which makes this concentration approach closely to its asymptotic value. Equations are given which enable these quantities to be determined. The quantities are determined for two reactor cycle times of 24 h and 48 h as functions of the neutron flux ($5 \times 10^{11}$ n/cm$^2$ per s $\leq \phi \leq 10^{14}$ n/cm$^2$ per s) and the reactor operating time per cycle. The calculations were carried out on a digital computer and the results are presented graphically. It is shown that the maximum $^{135}$Xe concentration in any reactor power period can occur at either the beginning or the end of that period, depending on the cycle time, the reactor operating time per cycle and the neutron flux. (auth) (UK)

**16249** REACTOR PHYSICS MEASUREMENTS ON $^{235}$U AND $^{239}$Pu FUELS IN AN INTERMEDIATE SPECTRUM ASSEMBLY. Fox, W. N.; King, D. C.; Pitcher, H. H. W.; Sanders, J. E. (Atomic Energy Establishment, Winfrith, Eng.). J. Brit. Nucl. Energy Soc., 9: 2-27(Jan 1970).

The reactor physics parameters of two intermediate spectrum systems, fuelled respectively by $^{235}$U and $^{239}$Pu homogeneously distributed in graphite, were measured using a mixed critical assembly in the reactor HECTOR. The null-reactivity method was used to obtain the k-infinity and the reaction rates were measured with fission chambers and $BF_3$ proportional counters. The results of the experiments provide a sensitive integral test of nuclear data in the resonance region, and comparisons with theoretical prediction are presented. (auth) (UK)

**16250** EXPERIMENTS ON REACTIVITY BALANCE AS MALFUNCTION DETECTOR FOR RESEARCH REACTOR. Fukutomi, Shigeki; Monta, Kazuo (Nippon Atomic Industry Group, Co., Kanagawa, Japan). J. Nucl. Sci. Technol. (Tokyo); 7: 54-6(Jan 1970).

The use of reactivity balance for detecting reactor malfunctions is described. The method is designed for a digital computer control system. Experimental application of the method is performed on the Toshiba Training Reactor 1. 2 references. (D.C.C.)

**16251** AUTOMATION OF REACTOR CONTROL AND SAFETY SYSTEMS AT ORNL. Oakes, L. C. Nucl. Safety; 11: 115-18(M (Mar-Apr 1970).

Reactor safety functions requiring fast response are automated, but objections arise when some traditionally manual operations are proposed for automation. In a reactor control system, perhaps more than in any other, the operator is dependent on sensory instrumentation for determining the operating state. Comparisons of reliability, operability, economics, and safety for automatic vs. manual control are about the same if similar performance is expected. These are exemplified by discussions of automatic startups and shimming. Operator justification is even now somewhat philosophical, and results of current research and development in computer control and diagnostic techniques will further tend to reduce his role. A greater amount of automation than now used would lead to improved safety and operability. 4 references (auth)

**16252** INTEGRAL EXPERIMENTS IN FAST ZERO POWER REACTORS. Engelmann, P. (Kernforschungszentrum, Karlsruhe, Ger.). Atomkernenergie; 15: 39-45(1970). (In German). (CONF-690419-5).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

Fast integral experiments play an important role in the development of fast power reactors. The experimental results can be used to check the nuclear data sets as well as the methods used in design calculations. In this way the uncertainties in the prediction of design parameters can be estimated and reduced. A survey on the various kinds of fast integral experiments and their purpose is presented. The experimental techniques used in these experiments are described. Further improvement of some of the methods is necessary especially for a systematic check of nuclear data. The various ways are discussed which lead from integral data to improved data sets. 45 references. (auth)

## Rocket and Space Reactors

*Refer also to abstracts 14647, 14662, 14663, and 16124.*

**16253** (AD-696628) SYSTEMS AND OPERATIONAL ANALYSIS OF NUCLEAR AND CHEMICAL ROCKETS: A BIBLIOGRAPHY. Peck, T. P. (General Dynamics/Astronautics, San Diego, Calif.). 12 Oct 1962. 10p. (GDA-AOC-62-0002-4). CFSTI.

A bibliography of periodic articles, documents, and books relative to chemical and nuclear space propulsion systems is presented. (USGRDR)

**16254** (N-69-40061) CHARACTERISTICS OF A 2.17-MEGAWATT FAST-SPECTRUM REACTOR CONCEPT USING AN AXIALLY MOVING REFLECTOR CONTROL SYSTEM. Mayo, Wendell; Whitmarsh, Charles L. Jr.; Miller, John V.; Allen, Hubert W. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Oct 1969. 28p. (NASA-TM-X-1911). CFSTI.

Neutronic, fluid flow, and heat-transfer calculations were performed for a reactor concept which makes extensive use of refractory metals for structure, cladding the UN fuel, and reflectors. $^7$Li is the coolant. A design objective of operation for 50,000 hours at 2.17 MW is achieved by fuel zoning to shape the power and the temperature distributions in the core and equalize fuel cladding stresses. Calculations show that reactivity control requirements can be met with an axially moving reflector outside of the pressure vessel. (auth) (STAR)

**16255** (N-69-40593) DEVELOPMENT OF EMITTERS AND COLLECTOR MULTILAYER SYSTEMS. Hubner, H.; (and others). Translated from a German research report. 118p. (NASA-TT-F-12570; W-68-57). CFSTI.

The described work is a part of an in-core-thermionic reactor development program. The system is proposed as an energy source for space vehicles. The thermionic element is built up of eight cells in a series with $UO_2$ pellets as fuel. The fission of gas of each emitter is vented separately to avoid swelling due to fission gas pressure at the designed fuel burn up. Adequate methods to prevent plugging of the venting system were investigated. An instrumentive capsule for in-pile-testing emitters at nominal and higher heat rating was designed and is now under construction.

W layers were deposited from the $W(CO)_6$. The interfacial diffusion of Mo–W was investigated. The joining technology for the design was developed. A method to build concentric collector systems (Nb–$Al_2O_3$Nb/1Zr) was proved with good success. (auth) (STAR)

16256 (N–70–11485) SNAP–8 NaK–PUMP–MOTOR–ASSEMBLY 400 HERTZ START TESTS. Boecker, Fred (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). 24 Nov 1969. 17p. (NASA–TM–X–52723). CFSTI.

Two hermetically–sealed induction motor–driven centrifugal pumps were tested to determine their ability to start on 400 hz power in eutectic NaK mixture loops at 70 to 1300 F. The NaK flow resistance was preset by a flow control valve prior to each start and corresponded to NaK flow rates after pump start from zero to 40,000 lb/hr. The two pumps started successfully on 400 hz power when the induction motor stator temperatures were 300 and 480 F with NaK pump inlet temperatures of 115 and 1300 F, respectively. Both pumps experienced startup difficulties when the motor stator temperatures were 70 to 140 F with NaK at the pump inlet at temperatures ranging from 70 to 600 F. (auth) (STAR)

16257 (N–70–11975) STUDY OF A 300–KILOWATT RANKINE–CYCLE ADVANCED NUCLEAR–ELECTRIC SPACE–POWER SYSTEM. Heller, Jack A.; Moss, Thomas A.; Barna, Gerald J. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Nov 1969. 37p. (NASA–TM–X–1919; E–5135). CFSTI.

A system analysis is presented for a nominal 300 kW(e) K system employing a Li–cooled fast reactor and with 2100 F (1420 K) turbine inlet temperature. Trends in performance and weight are discussed for variations in design parameters. Performance and design of major components are reviewed, including material considerations. A typical conceptual system layout is shown. (auth) (STAR)

16258 (N–70–12223) STUDIES OF NUCLEAR LIGHT BULB START–UP CONDITIONS AND ENGINE DYNAMICS. Latham, Thomas S.; Bauer, Harold E.; Rodgers, Richard J. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Sep 1969. Contract NASw–847. 112p. (NASA–CR–107046; H–910375–4). CFSTI.

Finite–difference approximations to the time–dependent thermal, fluid dynamics and neutron kinetics equations were used to describe the operating characteristics of the engine. These equations were programmed on a UNIVAC 1108 digital computer to construct a dynamic simulation for predicting the response of the engine to selected perturbations occurring at the nominal full–power operating condition. A preliminary transient analysis was performed using the model, which simulates an uncontrolled engine, to determine the basic stability characteristics and to identify the parameters which would provide the most effective control mechanisms. Responses to perturbations in the uncontrolled system can be characterized by either steady–state or damped oscillations with a characteristic frequency of about 1 Hz. It was concluded that control of the engine could be achieved primarily by control of fuel injection rate. (auth) (STAR)

16259 (N–70–12225) THEORETICAL INVESTIGATION OF THE RADIANT EMISSION SPECTRUM FROM THE FUEL REGION OF A NUCLEAR LIGHT BULB ENGINE. Krascella, N. L. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Oct 1969. Contract NASw–847. 80p. (NASA–CR–107049; H–910092–12). CFSTI.

A theoretical investigation was conducted to determine the spectral emission characteristics of the fuel region of a nuclear light bulb engine and hence, the spectral radiative flux incident upon the transparent containment walls or upon the reflective end walls of such an engine. The analysis was performed for a specified engine configuration and for a specific nuclear fuel partial pressure distribution. Estimates of the spectral radiative flux emanating from the nuclear fuel region were made for a total radiated flux of 24,300 Btu/sq ft–sec, which corresponds to an effective black–body radiating temperature of 15,000 R (8333 K). Six cases were considered in which the effects of changes in the heavy–atom absorption coefficient model parameters, the addition of a seeding gas, and changes in end–wall reflectivities on the spectral radiative flux emitted from the nuclear fuel region were examined. Three cases involved parametric variations of the heavy–atom model in either the fuel species ionization potentials or in the oscillator strength distribution functions describing line transitions. In the fourth case, the effect of hydrogen as a seed gas on the emitted spectral radiative flux was studied. The effect on the emitted flux of a uniform end–wall spectral reflectivity of 0.5 was examined in the fifth case; similar calculations were made in the sixth case using the spectral reflectivity of aluminum. (auth) (STAR)

16260 (N–70–12229) EXPERIMENTAL INVESTIGATIONS TO SIMULATE THE THERMAL ENVIRONMENT, TRANSPARENT WALLS, AND PROPELLANT HEATING IN A NUCLEAR LIGHT BULB ENGINE. Roman, Ward C.; Klein, John F.; Vogt, Paul G. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Sep 1969. Contract NASw–847. 123p. (NASA–CR–107048; H–910091–19). CFSTI.

Experiments were conducted to develop an intense radiant energy source capable of producing radiant energy fluxes within the range expected in nuclear light bulb engines. Concurrently, small–scale internally cooled fused silica models similar to the transparent walls proposed for the engine were developed and tested. Experiments to demonstrate heating of a seeded simulated propellant by thermal radiation passing through the transparent wall were also initiated. (auth) (STAR)

16261 (N–70–12322) COLD–FLOW STARTUP TEST SUMMARY OF A FULL–SCALE NUCLEAR ROCKET ENGINE USING A RADIAL TURBOPUMP. Petrik, Edward J.; Reardon, John E. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Dec 1969. 42p. (NASA–TM–X–1917). CFSTI.

Results are presented from an unfueled nuclear rocket simulator test conducted to determine if enough heat energy from the engine components is available to the turbine to start pumping propellant. The investigation was conducted with the pump at ambient and liquid–hydrogen temperatures and at tank pressures of 25 and 35 psia (17.2 and 24.1 N/sq cm) for both pump conditions. Data show a flow surge existed several seconds after power was applied to the turbine. Analysis indicates the flow surge experienced can be minimized either by flushing the system prior to applying power to the turbine or by programmed throttling at the pump discharge. (auth) (STAR)

16262 (N–70–12633) EVALUATION OF METHODS FOR COMPUTING NUCLEAR ROCKET RADIATION FIELDS. (Lockheed–Georgia Co., Marietta). [1969]. Contract NAS8–9500. 128p. (NASA–CR–102338; ER–8236). CFSTI.

The point–kernel, discrete ordinates, and Monte Carlo methods are compared emphasizing usefulness in analysis and design of nuclear rocket systems. Codes selected for investigation were the following: point–kernal programs 14–0(and 14.1), and QAD–P5 (and QAD–IV); discrete ordinates programs DDK and DTK; and Monte Carlo programs 18–0, MCS and MCG. The suitability of the point–kernel method for preliminary parametric studies, the Monte Carlo methods for design point verification, and discrete ordinates for estimation of fission and radiative capture distributions over the reactor–shield assemply was established. Other conclusions include: parametric point kernel neutron estimates should always be compared with a representative Monte Carlo computation performed simultaneously, and adjusted; MCS/MCG programs are preferable to the 18–0; two–dimensional DDK is preferred to the faster DTK; and assessment of differences in test–stand and deep–space radiation environments over the nuclear stage appears marginally feasible with the programs studied, but only with multiple computations of separate radiation components. (STAR)

16263 ANALYSIS OF THE KIWI–TNT EXPERIMENT WITH MARS CODE. Hirakawa, Naohiro (Japan Atomic Energy Research Inst., Ibaraki); Klickman, Alton E. J. Nucl. Sci. Technol. (Tokyo); 7: 1–6(Jan 1970).

The KIWI–TNT experiment was analyzed with a new two–dimensional excursion code MARS to ascertain the validity of the method used in calculating the energy release in the hypothetical accident analysis on fast reactors. In calculating the total energy release, adopting the nominal temperature coefficient, the present calculation was found to underestimate the total energy release by 9% in reference to the experimental value of $8.8 \times 10^9$ J. The calculated power pulse width was 1.1 msec, which is about half that was observed in the experiment. Adopting a temperature coefficient reduced to $0.5 \times 10^{-5}\ \Delta k/\Delta\theta$, the calculated energy release agrees with that of the experimental value, but then the discrepancy in power pulse width became the largest. Assumption that the expansion occurs in the axial direction only approaches the calculated energy release quite close to the values from experiment, although it still leaves a considerable disagreement in power pulse width. 9 references. (auth)

16264 NUCLEAR MANNED MISSIONS TO MARS IN THE 1980s. McKereghan, Charles D.; Friedlaender, Frank M. Astronaut. Aeronaut.; 8: No. 1, 62–6(Jan 1970).

A review of the present and planned developments in Mars ex-

ploration systems and vehicles is presented. The use of nuclear propulsion units in the manned Mars exploration program is described. 2 references. (D.C.C.)

## Process Heat and Desalination Reactors

16265 (CONF-690218-1) NUCLEAR DESALINATION INSTALLATIONS: PRESENT AND FUTURE. Ramey, James T. (Atomic Energy Commission, Washington, D. C.). [1969]. 23p. (In Italian). Dep. CFSTI (U. S. Sales Only).

From International Conference on Water Purification and Desalination, Rome, Italy.

The economics of using power for desalination is discussed. The development of reactor technology to accommodate the needs for desalting purposes is considered. Efforts toward nuclear desalination realization are summarized for Israel, Mexico, and New York. The concept of the agro-industrial complex is presented. The necessity of a demonstration plant is discussed. 8 references. (M.L.S.)

16266 CHALLENGE TO NUCLEAR IRON-MANUFACTURE. Yoshida, Michikazu (Iron and Steel Inst. of Japan, Tokyo). Denryoku Shinpo; 15: No. 11, 32-8(Nov 1969). (In Japanese).

The total production of crude steel in Japan is expected to reach 85,000,000 tons in 1969. Nuclear energy, both in the form of heat and electric power, is quickly becoming an economic industrial tool. Challenge to nuclear iron-manufacture in Japan is described on the following: energy problems in the iron and steel industry; development in the multipurpose utilization of nuclear reactors; use of nuclear electric power in iron and steel industry; utilization of nuclear heat in the processes of iron manufacture; development of a high-temperature helium-cooled reactor for iron manufacture; and prospects for the future. (NSA of Japan)

## Marine and Portable Power Reactors

*Refer also to abstract 16124.*

16267 (AD-696415) MH-1A FLOATING NUCLEAR POWER PLANT: REPORT ON FINAL TRIALS TESTING. DESCRIPTION OF TESTS PERFORMED PRIOR TO AND DURING INITIAL START-UP. Final Report, April 1967-July 1968. Black, Francis M.; Beyer, George L. (Army Engineer Reactors Group, Fort Belvoir, Va. Engineering Div.). 5 Oct 1969. 326p. (ED-6912). CFSTI.

The MH-1A Floating Nuclear Power Plant was at Fort Belvoir from April 1967 to July 1968 for operational testing to demonstrate acceptability under the construction contract. The testing and operations performed by the contractor and the Government has proven the design and operational procedures of the MH-1A to be safe for continued operation. (USGRDR)

16268 MUTSU JAPAN'S NUCLEAR MERCHANT SHIP. Mar. Eng. Nav. Architect; 92: 289-93(Jul 1969).

Particulars of the ship are listed and the layout shown. The propulsion plant, containment vessel and radiation shield are discussed. The safety precautions employed are emphasized. (UK)

## Production Reactors

*Refer also to abstract 16124.*

16269 VENTILATION FOR CONTROL OF TRITIUM AIR CONTAMINATION DURING REACTOR VESSEL REPAIR. Caldwell, R. D.; Cooley, R. C. (E. I. du Pont de Nemours and Co., Aiken, S. C.). Health Phys.; 18: 167(Feb 1970).

The necessity of wearing bulky protective clothing, because of health hazards arising from high tritium concentration in air during reactor vessel repair at Savannah River Plant nuclear reactors, resulted in increased repair time and cost. To overcome this health hazard a ventilation system was designed using two, 24 × 24 × 11 in. High Efficiency Particulate Air filters connected in parallel and having 2000 $ft^3$/min total nominal capacity to remove radioactive particulate matter. An estimated time saving of 30 days and cost saving of $25,000 is quoted. (UK)

## Reactor Theory

### Kinetics

*Refer also to abstracts 14246, 16155, 16156, 16159, 16160, and 16171.*

16270 (BARC-418) THEORETICAL REACTOR PHYSICS STUDIES. Annual Progress Report, 1967. Rastogi, B. P. (Bhabha Atomic Research Centre, Bombay (India)). 1969. 21p. Dep. CFSTI (U. S. Sales Only).

Summaries of various studies are presented. (J.M.J.)

16271 (BNL-50117, pp 140-63) ASYMPTOTIC STABILITY OF REACTORS WITH ARBITRARY FEEDBACK. Akcasu, A. Z.; Akhtar, P. (Michigan Univ., Ann Arbor. Dept. of Nuclear Engineering).

16272 (BNL-50117, pp 166-73) NUCLEAR REACTOR KINETICS RESEARCH AT THE UNIVERSITY OF FLORIDA. Uhrig, R. E.; Ohanian, M. J. (Florida Univ., Gainesville).

Research programs in reactor kinetics at the University of Florida are described. Topics reviewed include: reactor noise measurements; neutron-wave and -pulse propagation studies; and conventional die-away techniques. (16 references) (D.C.C.)

16273 (BNL-50117, pp 174-91) BERKELEY KINETIC STUDIES. Chambre, P. L.; Grossman, L. M.; Pigford, T. H.; Ruby, L.; Schrock, V. E.; Smith, H. P. Jr. (California Univ., Berkeley. Dept. of Nuclear Engineering).

Results of research programs in reactor kinetics conducted at the University of California Berkeley are presented. Topics reviewed include: space-time kinetics; pulsed-neutron and statistical studies in multiplying systems; optimal control of nuclear reactor systems; fission gas dynamics; explosive disassembly of fast-spectrum power reactors; reactor heat transients; and propagation of pressure waves in two-phase media. (30 references) (D.C.C.)

16274 (BNL-50117, pp 192-212) ACCURACY OF THE QUASISTATIC TREATMENT OF SPATIAL REACTOR KINETICS. Ott, K. O. (Purdue Univ., Lafayette, Ind.); Meneley, D. A. (Argonne National Lab., Ill.).

A quasistatic method for fast reactor kinetics is described. The computer program QX1 is formulated from the quasistatic method. Results of the quasistatic method are compared with direct numerical solutions. (21 references) (D.C.C.)

16275 (CEA-N-1243) NEUTRON THERMALIZATION STUDIES [AT THE SACLAY CENTER]: DATA LIBRARIES, METHODS, AND CODES FOR CELL CALCULATION. Livolant, Michel (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Jan 1970. 34p. (In French). Dep. CFSTI (U. S. Sales Only).

Calculation methods and computation facilities available at the Service of Mathematical Physics of the Saclay Nuclear Center for neutron transport thermalization problems, and special reactor cell problems are described. The first part deals with cross sections. A brief review of the formalism used for obtaining transfer cross sections in the harmonic approximation from the fundamental experimental data (frequency spectrum of interatomic and intermolecular vibrations) is given. The sequence of codes used to obtain multigroup cross sections and G and H functions (Cadilhac model) is described. The reactor cell calculation methods are the subject of the second part. Two different methods are used: the integral transport and multigroup cross sections method (THERMOS type), the "flat source zones" and Cadilhac model method (DEP 035, PROSPERE, COELACANTHE. . .). A detailed comparison of these various codes (accuracy, physical and geometrical possibilities, computation time) provides a general check of their validity and gives the information needed to choose the most convenient one for each physical situation. 24 references. (auth) (France)

16276 (GEAP-4922(Suppl.1)) BISYN: A TWO-DIMENSIONAL SYNTHESIS PROGRAM. Greebler, P.; Gyorey, G. L.; Hutchins, B. A.; Kelly, M. D. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Dec 1968. Contract AT(04-3)-189. 61p. Dep. CFSTI.

Equations for eigenvalue and final flux solutions for the BISYN fast reactor digital code are derived. The code reduces a two-dimensional adjoint-weighted diffusion equations to one-dimensional equations, using a variational principle. Equations for the $\psi$ shape function solutions are derived. Input/output format is described; error statements are listed. Storage locations and areas are defined. A sample problem is included. 8 references. (M.L.S.)

16277 (IN-1356) RELATIVE IMPORTANCE OF DELAYED NEUTRONS IN FEW-GROUP REACTOR KINETIC CALCULATIONS. Putnam, G. E. (Idaho Nuclear Corp., Idaho Falls). Jan 1970. Contract AT(10-1)-1230. 31p. Dep. CFSTI.

It was found that a failure to account for the importance of the delayed neutrons relative to the prompt ones in few-group reactor kinetics calculations can cause large errors in the predicted as-

ymptotic behavior. An approximate method is presented that removes the source of these errors by quite effectively accounting for the relative importance of the delayed neutrons in each neutron energy group. (auth)

16278 (JAERI-1186) NESAP-2: A FORTRAN-IV CODE FOR CALCULATION OF NOISE SPECTRA IN AT-POWER REACTORS. Saito, Keiichi (Japan Atomic Energy Research Inst., Tokai. Tokai Research Establishment). May 1969. 39p. (In Japanese and English). Dep. CFSTI (U. S. Sales Only).

The present code obtains neutron and temperature noise spectral density in at-power reactors on one-space-point model which has a single group of delayed neutrons and two loops of reactivity feedback via fuel and moderator (including coolant) temperature. Noise-equivalent sources are determined by the generalized Schottky formula. Extraneous noise-equivalent source with the first-order delay effect is also taken into account. Thermal energies exchanged between fuel and moderator, or removed from coolant by an elementary stochastic event are, however, unknown statistical parameters. It is possible, to perform a parametric survey on these unknowns. An auxiliary routine synthesizes theoretical components of the input noise source by the least square method so as to give the best fit to an experimentally obtained input noise source and determines the values of the unknowns. 25 references. (auth)

16279 (KAPL-P-3871) DATATRAN EXPERIENCE. Kopp, H. J. (Knolls Atomic Power Lab., Schenectady, N. Y.). [1967]. Contract W-31-109-eng-52. 4p. (CONF-690401-3). Dep. CFSTI.

From Conference on the Effective Use of Computers in the Nuclear Industry, Knoxville, Tenn.

The syntax-oriented computer language DATATRAN that serves as a supplement to FORTRAN for data file management and program interfacing is briefly described. Examples that illustrate applications to practical problems are outlined. Compatibility of DATATRAN–NOVA systems is discussed. (W.H.K.)

16280 (KFK-tr-301) EVALUATION OF THE REQUIRED ACCURACY OF CONSTANTS FOR CALCULATION OF FAST POWER REACTORS. Zaritskii, S. M.; Troyanov, M. F. Translated from International Conference on the Physics of Fast Reactor Operation and Design, London, 24–26 June 1969. 18p. (In German). (CONF-690634-1). Dep. CFSTI (U. S. Sales Only).

Multiplication factor ($k_{eff}$) and breeding rate (BR) are the two most important parameters for evaluating a large fast breeder power reactor. These parameters are calculated from nuclear constants such as neutron capture cross section and fission cross section. The necessary mathematical formulas are developed, especially with accuracy requirements of the constants in question, and, are applied to several $^{239}Pu$–$^{238}U$ combinations. One table contains the key parameters for various core arrangements. Two additional tables show the relationship between $k_{eff}$ and BR to various nuclear constants of $^{239}Pu$ and $^{238}U$. (H.B.G.)

16281 (ORNL-TM-2496(Rev.1)) NUCLEAR REACTOR CORE ANALYSIS CODE: CITATION. Fowler, T. B.; Vondy, D. R. (Oak Ridge National Lab., Tenn.). Jul 1969; Revision 1: Jan 1970. Contract W-7405-eng-26. 204p. Dep. CFSTI.

A manual describing the use of the machine program CITATION is presented. Sections are included which present auxiliary information needed by the user and mathematical formulations. This code is intended to be a generalized computer code for analysis of nuclear reactor cores with treatment of one to three space dimensions. It has been organized to treat a wide variety of different types of calculations using an IBM-360/91 or an IBM-360/75 computer with bulk storage, or any equivalent computer with a large fast memory. Given such required data as broad-group microscopic neutron-nuclide reaction cross sections, depletion, dynamics, or static problems may be solved. Programming effort has been directed toward generalizing calculations, such as fuel management, so that the actual neutron flux calculation may involve any of a variety of different approaches. Thus the neutron accounting or eigenvalue problem may be done by one of a variety of methods and the results used in depletion or dynamics calculations. Initial effort has gone into the finite-difference diffusion theory approximation to neutron transport. (auth)

16282 (ORNL-TM-2786) SSF: A FORTRAN IV PROGRAM FOR COMPUTING SELF-SHIELDING FACTORS. Carlsmith, R. S.; Steiner, D. (Oak Ridge National Lab., Tenn.); Lucius, J. L. (Union Carbide Corp., Oak Ridge, Tenn. Computing Technology Center). 19 Dec 1969. 15p. Dep. CFSTI.

A computer program which determines flux ratios and self-shielding factors for a 2 region cell is described. The self-shielding factors may be input to a GAM-II calculation by use of an automated linkage option. The use of this program requires a familiarity with the GAM-II equations and input. (auth)

16283 (RPI-328-163) TIME-SYNTHESIS USING DISCONTINUOUS GREEN'S FUNCTION MODES. Rohr, Paul C.; Becker, Martin (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Nuclear Science). [1968]. Contract AT(30-3)-328. 7p. (CONF-691102-19). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

An application of current- and flux-gradient-trial functions in predicting power responses for reactors in which half-core perturbations have taken place. Results are shown of a half-core step perturbation introduced at time zero with a stronger opposite half-core perturbation being introduced at a later time. (M.L.S.)

16284 (RPI-328-164) NEUTRON SLOWING DOWN IN MIXTURES CONTAINING SCATTERING RESONANCES. Dunn, Floyd E.; Becker, Martin (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Nuclear Science). [1969]. Contract AT(30-3)-328. 7p. (CONF-691102-16). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

16285 (RPI-328-165) APPLICATION OF ANALYTIC METHODS TO FAST REACTOR SPECTRA. Dunn, Floyd E.; Becker, Martin (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Nuclear Science). [1968]. Contract AT(30-3)-328. 7p. (CONF-691102-17). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

16286 (WANL-TME-1970) UTILITY PROGRAMS FOR GAMB1T THERMAL RANGE LIBRARY. Collier, G.; Moran, L. L. (Westinghouse Electric Corp., Pittsburgh, Pa. Astronuclear Lab.). Oct 1969. 89p. Dep. CFSTI.

The three utility programs which create and verify thermal range libraries for the GAMBIT program are described. UPDATE creates the thermal range library. MODPLOT performs a check on moderator kernels and produces a plot of the results. GAB creates a gas library for the linkage in the GAMBIT program. (auth)

16287 (WAPD-TM-773) GAUSSIAN QUADRATURE FOR CERTAIN INTEGRALS WITH WEIGHT FUNCTION $EXP(-X^2)$ (LWBR DEVELOPMENT PROGRAM). Steen, N. M. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Jan 1970. Contract AT-11-1-GEN-14. 112p. Dep. CFSTI.

Gaussian quadratures for the definite integrals $\int_0^\infty e^{-x^2} f(x)dx$ and $\int_0^\infty e^{-x} f(x)\,dx$ are developed and the weights and abscissae tabulated to 15 places using up to 15 points for the semi-infinite interval. Weights and abscissae for quadratures are provided for the finite intervals with $0.3 \le b \le 1.0$ in steps of 0.05, and for $0.05 \le b \le 0.25$ in steps of 0.05. The basic notion of Gaussian quadrature is discussed and placed in a proper perspective in the class of interpolatory quadratures. Proof of convergence is given for a large class of functions which is not available in most works on the subject. 25 references. (auth)

16288 SOME BASIC RELATIONS IN THE WAITING TIME ANALYSIS OF NEUTRON COUNTING STATISTICS. Saito, Keiichi (Japan Atomic Energy Research Inst., Ibaraki). J. Nucl. Sci. Technol. (Tokyo), 6: 604-7(Oct, 1969).

Methods for analyzing neutron counting statistics for reactor physics measurements are discussed. Equations which describe the relation of the correlation function to the variance of the counts are formulated. Probabilities for obtaining a certain number of counts in a given time interval are defined. 16 references. (M.L.S.)

16289 APPLICABILITY OF SELF-CONSISTENT ONE DIMENSIONAL ANALYSIS TO VERY SMALL REFLECTED CYLINDRICAL FAST ASSEMBLIES. Lee, S. M.; Kapil, S. K. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 327-31 (1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

16290 DERIVATION OF VARIATIONAL PRINCIPLES. Dwivedi, S. R. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 332-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Variational principles are derived for a differential operator using Hamilton's Principle. The variational principles for an arbitrary function of the solution of the given equation as presented by Pomraning are derived. 6 references. (D.C.C.)

16291 INTEGRATION OF THE POINT-REACTOR KINETIC EQUATIONS WITH A PERIODIC REACTIVITY INPUT BY USE OF

QUASI-PERIODIC VECTOR SOLUTIONS. Trasi, M. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 347-50(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

16292 COMPUTER-AIDED ANALYSIS OF NUCLEAR REACTOR KINETICS. Vreeke, Simon Abraham. Salt Lake City; Univ. of Utah (1969). 270p.

Thesis.

A computer aided technique using an interactive graphics system is used to examine nonlinear point nuclear reactor kinetics problems. From the graphical output displayed on the CRT terminal the general solution of any system of autonomous differential equations whose solutions are amenable to a geometric interpretation in phase space can be studied. The canonical formulation is utilized in order to obtain the most informative projection planes for third order systems. Concepts concerning stability of the actual formulation of a mathematical model and its solutions are examined. Interactively it is possible to examine various forms of solutions which are of interest such as the solutions of the linear approximation, phase space solutions, particular solutions as functions of the independent variable, and the solutions of the canonical formulation. It is also possible to change step sizes in the algorithms, to change regions of interest, to display important functions, and to perform parametric studies. Numerous additional options render the method an efficient and direct tool for studying systems of nonlinear differential equations. Various nuclear reactor kinetics models of both second and third order are analyzed for reactivities which are either functions of temperature or xenon. The effects of delayed neutrons are included by using a constant effective generation time or by making the effective generation time a function of reactivity and its derivative. Applying Bendixson's theorem to second order systems it is found that the limit cycles do not exist for those temperature dependent models for which the rate of temperature change is a monotonic function of temperature. Both the two-temperature reactor and the xenon controlled reactor are considered as third order systems. For these third order systems the nonlinear system will exhibit limit cycles in the region of parameter space where the linear system exhibits an unstable saddle focal point. However, the region of parameter space which exhibits limit cycles of sufficiently small magnitude to be of benefit in the control of the reactor is small. (Diss. Abstr.)

16293 REFLECTION AND TRANSMISSION FUNCTIONS IN REACTOR PHYSICS. Pfeiffer, Wayne Wallace. Pasadena, Calif.; California Inst. of Tech. (1969). 122p.

Thesis.

The utility of reflection and transmission function (or collectively, response function) concepts in reactor physics is extensively investigated. Previously obtained differential (invariant imbedding) and functional (adding) equations for the response functions are rederived in a unified manner. In addition a numerical halving technique is developed from the adding relations. Existing response function calculations are summarized and extended by combining the invariant imbedding and functional equations. For deep-penetration shielding problems in slab geometry, this combined response function approach is shown to be more efficient than conventional Monte Carlo or discrete ordinates techniques. The response function approach is also shown to be efficient for a criticality search in slab geometry. As a step toward a more general treatment, invariant imbedding equations are derived, but not solved, in finite cylindrical geometry. Finally the feasibility of performing response function experiments to obtain cross-section and criticality information is examined. The envisioned experimental set-up is described and calculations are carried out to verify the analytical procedures, with particular emphasis on the propagation of errors. Cross-sections can be determined using the halving scheme, which provides a theoretically sound technique for multiple scattering correction. Thus experiments may be done on moderately thick slabs. Criticality parameters can be obtained from measured response functions using the criticality search procedure. Because response function experiments are expected to be relatively quick and cheap compared to present cross-section and critical experiments, it is concluded that response function experiments should be carried out as soon as possible to determine whether they are as useful as our analysis indicates. (Diss. Abstr.)

16294 WEIGHTED RESIDUAL METHODS IN SPACE-DEPENDENT REACTOR DYNAMICS. Fuller III, Edward Lewis. Tucson, Ariz.; Univ. of Arizona (1969). 159p.

Thesis.

Approximate methods for the solution of problems in space-dependent nuclear reactor dynamics are studied. It is shown that these approximate methods, which include the point reactor model, modal expansion methods, synthesis methods, variational methods, and discontinuous trial function methods, can all be thought of as applications of the method of weighted residuals. In each method, a trial solution is formed for the neutron flux. The trial solutions are expansions in known spatially dependent functions called trial functions. The undetermined time-dependent functions, called amplitude functions, are then found by using the weighted residual procedure known as the method of undetermined functions to derive the so-called multimode kinetics equations, which are first order, ordinary differential equations in time. Each approximate method differs from the others in the manner in which its trial functions are chosen. For example, the point reactor model and modal methods generally use the steady-state flux distribution. Synthesis methods use flux distributions found by solving lower dimensional problems. Quasistatic methods periodically recalculate the spatial distribution. The variational method consists of two complementary weighted residual methods in which the trial functions for the adjoint system are the weighting functions for the real system, and vice-versa. Methods involving spatially discontinuous trial functions are discussed, with particular attention paid to multichannel synthesis. Weighted residual methods of treating interface conditions are developed and applied to a derivation of the multimode kinetics equations for multichannel synthesis. The differences between partial current weighting and surface cancellation weighting of interface conditions are pointed out. It is shown that a nodal method results when one mode is used for each channel. Temporally discontinuous trial function methods are also treated. A weighted residual procedure is used to show how the "new initial conditions" are found for the amplitude functions following the introduction (or deletion) of a trial function or a set of trial functions. Quasistatic methods are discussed within the framework of temporally discontinuous trial function methods, and an application of the modal method to improve the quasistatic shape functions is described. The multimode kinetics equations are integrated using the method of undetermined parameters. This enables the finite difference time-step limitation, which is caused by the multiplication of the time derivative terms by very small parameters, to be overcome. Piecewise polynomial functions are used as trial functions. Three choices of weighting functions are considered: collocation weighting, subdomain weighting, and Galerkin weighting. An iterative method, which uses the method of undetermined functions for both spatial and temporal integrations, is described. It eliminates the need for choosing accurate trial functions because it finds a solution which is independent of the initial choice of trial functions. A simple example is solved to illustrate the method. Several possible applications of the method are indicated. These include use with temporally discontinuous trial function methods, use with multichannel synthesis, and use for solving the full three-dimensional time-dependent problem. Some numerical results are reported for continuous synthesis and multichannel synthesis approximations. Only one energy group is used. Several choices of weighting functions are compared. Conclusions are drawn regarding the roles of the trial functions and the weighting functions in obtaining accurate solutions. Two different methods of weighting interface conditions are compared for multichannel synthesis. In addition, the ability of the multichannel synthesis method to form an accurate solution beginning with a poor set of trial functions is established. (Diss. Abstr.)

16295 APPLICATIONS OF LANGEVIN'S METHOD TO SOME REACTOR-RELATED FLUCTUATION PROBLEMS. Nieto, Juan Maria. Ann Arbor, Mich.; Univ. of Michigan (1969). 119p.

Thesis.

Langevin's technique is applied to three types of problems. First, the filtering effects of detectors used in fluctuation measurements are investigated. General results are obtained which are applicable to a large class of detection systems. Application is made to a Gas-filled $BF_3$ chamber and explicit break frequencies appear in the spectral densities of the fluctuations of the currents in the external circuitry of the detectors corresponding to average inverse ion and electron collection times in the detectors. Second, a two-energy group reactor model with delayed neutrons is investigated. Power Spectral Densities for the detection rates in both groups are obtained as well as the Cross-Power Spectral Density of the fast with the thermal reaction rates. The possibility of observing additional break frequencies to those provided by a one-energy group reactor model is shown. Third, the space-dependent theory of the fluctuations of prompt fast gammas from fission is investigated. The connection between the spectral density of the gamma fluctuations and that of the neutron fluctuations is obtained. Application of the general results is made to a finite, convex, homogeneous thermal reactor in which the neutrons are described by a space dependent thermal model in which diffusion while slowing down is approximately accounted for, and the gammas are described by a space dependent model in which diffu-

sion is neglected but streaming is allowed. Further application is made to a spherical reactor. The effects of the finite aperture of the detectors are investigated and some practical limits are discussed. (Diss. Abstr.)

16296 NONLINEAR OSCILLATIONS AND STABILITY OF A NUCLEAR REACTOR WITH TWO REACTIVITY FEEDBACKS. Schmidt, Theodore Reinold Jr. Tucson, Ariz.; Univ. of Arizona (1969). 185p.

Thesis.

The autonomous nonlinear differential equations describing the dynamic behavior of nuclear reactors with two reactivity feedbacks are analysed for stability and for the possibility of nonlinear oscillatory solutions. Fourier series expansions of the reactivity and power are used to search for limit cycles, successive approximations being generated by starting from the linear results. In the earlier work using this method, the second approximation for the amplitude of the reactivity was derived assuming that the feedback contained the fundamental frequency only. In this study, higher approximations including feedback from higher harmonic frequencies are derived for not only the amplitude of the reactivity but also the amplitude of the power. The effective lifetime model and the prompt jump approximation with one group of delayed neutrons are the two models used for the neutron kinetics. This permits an analysis of the effect of delayed neutrons on oscillations since both models are the same for small amplitude low-frequency oscillations. The most general linear heat transfer equations for two regions are described and the linear transformation for decoupling the equations is derived. A special set of two-region heat transfer equations is discussed which describes the heat transfer in a nuclear reactor with in-core thermionic converters. Linear stability is examined by applying the Routh criterion and plotting stability boundaries in a parameter space of reactivity coefficients. Nonlinear stability is discussed in terms of Welton's criterion, boundedness, finite escape times, and limit cycles. The results obtained with the Fourier series method are compared with exact solutions obtained from analog and digital computations. Accurate prediction of limit cycles by Fourier series is found when the operating power is near the critical power for linear stability, but only in the highest approximation used. The system of equations with effective lifetime kinetics yields stable limit cycles only, while the system of equations with the prompt jump approximation yields both stable and unstable limit cycles. Also, solution trajectories between the shutdown and operating equilibrium points exhibit some differences with the two kinetics models. The thermionic reactor system is restricted to physically meaningful parameters and then analyzed for stability. The exact solution indicates that the thermionic reactor system may be very stable. (Diss. Abstr.)

16297 CORRELATION BETWEEN GROUP CROSS SECTIONS TO BE ADJUSTED BY USE OF INTEGRAL DATA. Mitani, Hiroshi; Kuroi, Hideo (Japan Atomic Energy Research Inst., Ibaraki). J. Nucl. Sci. Technol. (Tokyo); 7: 56-9(Jan 1970).

16298 COMBINED DIFFUSION AND KINETIC METHOD FOR SOLVING THE TRANSPORT EQUATION. Voronkov, A. V.; Chuyanov, V. A. At. Energ. (USSR); 27: 344-6(Oct 1969). (In Russian).

A new method was developed for the precise solution of the transport equation for reactors containing strongly absorbing zones or cavities, in connection with the $P_N$ approximation of the spheric harmonics method. In order to simplify the problem, a one-dimensional geometry was used. The reactor was divided in 2 regions: Region I with $0 \leq r < r_0$, in which the transport equation is solved exactly, and Region II with $r_0 \leq r < R$ in which the $P_N$ approximation is used, whereby $r_0$ is the boundary between the regions and R is the boundary of the reactor or the cell. The method may be generalized for any position of Region I and for multidimensional geometry; solutions were presented for the two-group calculation of a three-region cylindrical cell. (TTT)

16299 INVESTIGATIONS OF THE DECAY OF A PULSED NEUTRON DISTRIBUTION BY THE IT-METHOD. Hembd, H. (CCR, Ispra, Italy). Atomkernenergie; 15: 56-8(1970). (CONF-690419-7).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

The IT-method is a new analytical method based on integral transform techniques to solve time and energy dependent neutron transport problems in various geometries. It works in large as well as small systems, the convergence being the better the smaller the size of the size of the system. The method is applied to moderators of spherical and plane shape in order to determine the "critical dimension" below which no fundamental mode can exist. The scattering models used are the free gas model with different mass numbers and the synthetic model of Corngold. 8 references. (auth)

## Dynamics

*Refer also to abstract 16009.*

16300 (BNL-50117, pp 106-39) SOME RECENT ADVANCES IN REACTOR DYNAMICS AND CONTROL. Hetrick, D. L.; Weaver, L. E. (Arizona Univ., Tucson. Dept. of Nuclear Engineering).

Results of research programs in reactor dynamics and control conducted at the University of Arizona are presented. Topics reviewed include: effects of delayed neutrons on stability of the two-temperature reactor model; a new analytical treatment of self-limiting power excursions near prompt critical; comparative studies of numerical methods for reactor dynamics; state variable feedback design of reactor control systems; and computation of regions of constrained stability for nonlinear reactor systems. (47 references) (D.C.C.)

16301 (BNL-50117, pp 306-21) APPLICATION OF LIE SERIES TO TIME DEPENDENT REACTOR THEORY. Auerbach, T.; Mennig, J.; Sarlos, G. (Eidgenoessisches Institut fuer Reaktorforschung, Wuerenlingen (Switzerland)).

A brief summary of the Lie series formalism due to Gröbner is presented, followed by a discussion of the recursive method actually used for solving time dependent problems. Applications of Lie series to 4 problems in reactor dynamics are included. (14 references) (D.C.C.)

16302 (HPR-106) COVARIANCE ANALYSIS IN THE DESIGN OF MODELS AND MONITOR PATTERNS FOR ON-LINE COMPUTER CONTROL OF MULTIVARIABLE PROCESSES. Grumbach, Rainer (Institutt for Atomenergi, Halden (Norway). OECD Halden Reaktor Prosjekt). Aug 1969. 31p. Dep. CFSTI (U. S. Sales Only).

A method for selection of optimum control processes in an operating reactor is given. The flow diagram for both the emergency action and normal operating control modes is shown. Mathematical models are developed for the observation-decision process to be initiated by the controller; the covariance method is used for these developments. 5 references. (M.L.S.)

## Experimental Applications

*Refer also to abstracts 16155, 16157, 16172, 16173, 16238, 16244, 16246, 16247, 16262, and 16263.*

16303 (AECL-3038) FISSPROD: A G-20 COMPUTER PROGRAM. Lane, F. E. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Nov 1969. 47p. Dep. CFSTI (U. S. Sales Only). AECL $1.50.

FISSPROD is a computer program to calculate the concentrations and total neutron absorption of up to 200 fission product nuclides. The accumulation and decay of the fission products are described by a system of first order differential equations which is represented and solved in the program as a lower triangular matrix equation. FISSPROD is written in APEX-IV, an ALGOL-like computer language developed at CRNL for the CDC G-20 computer. (auth)

16304 (BNL-50117, pp 40-54) REACTOR KINETIC CONSIDERATIONS IN HIGH-TEMPERATURE GAS-COOLED REACTORS. Peak, J. C. (Gulf General Atomic, Inc., San Diego, Calif.).

A description of various one-dimensional and two-dimensional reactor kinetic codes is presented. Comparisons of calculational models for kinetics of a 3m TRIGA core are included. (12 references) (D.C.C.)

16305 (BNL-50117, pp 55-76) METHOD FOR THE STUDY OF AUTOCATALYSIS AND/OR PRESSURE HISTORIES IN FAST BREEDER REACTOR EXCURSIONS. Moss, L. I.; Rhoades, W. A. (Atomics International, Canoga Park, Calif.).

The FRAP computer code for transient analysis in fast breeder reactors is described. The computer code provides accurate assumptions for fast breeder reactor transient conditions that are not available with the Bethe-Tait method of analysis. (13 references) (D.C.C.)

16306 (BNL-50117, pp 213-29) REACTOR KINETICS WORK AT ORNL. Perry, A. M. (Oak Ridge National Lab., Tenn.).

A brief review of several programs in reactor kinetics at ORNL is presented. Topics reviewed include: neutron density fluctuations; pulsed-source measurements in subcritical reactors; and circulating-fuel reactors. (10 references) (D.C.C.)

16307 (BNWL-1278) EVALUATION OF HYBRID COMPUTER PERFORMANCE ON A CROSS SECTION OF SCIENTIFIC PROBLEMS. Benham, R. D. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 76p. Dep. CFSTI.

The use of hybrid and small digital computers for application of scaled analog/digital simulation techniques is described. The hybrid computer software system is called SIMPL-1 and is implemented on a PDP-7 digital computer and an EASE 2133 analog computer designated PNL-1. The performance of the hybrid system is analyzed for the following problems: U. S. nuclear power economy; reactor vessel dynamics; nuclear plant dynamics; river water quality dynamics; metal annealing; reactor core design; steam particle deposition; fuel sintering; ultra-centrifuge data analysis; smoke pollution dynamics; ground water systems analysis; and two-group diffusion equation. 19 references. (D.C.C.)

16308 (BNWL-1291) A USER'S MANUAL FOR 2DBS, A DIFFUSION THEORY SHIELDING CODE. Marr, D. R. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb 1970. Contract AT(45-1)-1830. 41p. Dep. CFSTI.

Revisions were made in the two-dimensional, multigroup neutron diffusion code 2DB to facilitate its use in shielding calculations. The revised code, 2DBS, employs the same basic mathematical model. Changes were made to increase the rate of convergence and to improve monitoring and control of the convergence process, particularly for points far from the source; and to incorporate additional versatility in input and output, including linkages to a flux plotting routine. All programming is in FORTRAN-IV. 4 references. (auth)

16309 (KFK-1050) CRASH: A COMPUTER PROGRAMME FOR THE ANALYSIS OF CREEP AND PLASTICITY IN FUEL PIN SHEATHS. Guyette, M. (Kernforschungszentrum, Karlsruse (West Germany). Institut fuer Angewandte Reaktorphysik). Aug 1969. 77p. Dep. CFSTI (U. S. Sales Only).

A computer program, calculating the thermal and mechanical behavior of fuel pin sheaths, has been written in the framework of the development of the Na cooled fast breeder reactor SNR. This program, named CRASH (CReep Analysis in a fuel pin SHeath), calculates the tri-axial stress and strain states when creep or plasticity takes place in the material. The basic assumption for this calculation is the axi-symmetry of the sheath. The loads, which can be taken into account by the program, are: an outer pressure, an inner pressure, a temperature gradient and a fuel-clad radial and axial interaction. These loads can be any functions of time. (14 references) (auth)

16310 (WANL-TME-1969) SECOND VERSION OF THE GAMB1T CODE. Collier, G.; Gibson, Gordon; Moran, L. L.; Disney, R. K.; Kaiser, R. S. (Westinghouse Electric Corp., Pittsburgh, Pa. Astronuclear Lab.). Nov 1969. 95p. Dep. CFSTI.

The changes involved in the second version of the GAMBIT computer program are described. Results of six sample problems are included. Input instructions are listed. (11 references) (D.C.C.)

16311 NEUTRON CAVITY AMPLIFIER. Joneja, O. P.; Navalkar, M. P.; Iyengar, P. K. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 336-41(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

The effects of moderator geometry on the neutron intensity in a required direction are analyzed. The effect of a moderator cavity on the angular distribution of neutrons emerging particularly in a small solid angle in the forward direction is described. (auth)

16312 MEASUREMENT OF FAST NEUTRON SPECTRUM USING THRESHOLD DETECTORS. Ramakrishna, D. V. S.; Joneja, O. P.; Navalkar, M. P. (Bhabha Atomic Research Centre, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 356-60(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

16313 INTERCOMPARISON CALCULATIONS OF LARGE FAST REACTORS. Shankar Singh, R. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 416-20(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Physics measurements for large fast reactors are compared with 22 group cross section data. The calculations include self-shielding effects. Results for core volumes of 800 and 20000 liters are presented. Parameters calculated include: critical mass; breeding ratios; Doppler coefficients; Na void effects; and neutron spectra. 4 references. (D.C.C.)

16314 EXPERIMENTS ON PILE PHYSICS BY MEANS OF TOF NEUTRON DIFFRACTION. Kimura, Motoharu; Watanabe, Noboru (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 2: No. 1, 97-107(Jun 1969). (In Japanese).

Measurement of thermalization process of neutrons in fundamental moderators was made by means of T-O-F neutron diffraction. The moderator used in the experiment was $H_2O$ and BeO. The improvement of experimental apparatus and method was pursued. As a result, time resolution was considerably improved for $H_2O$. As for the crystalline moderator of BeO, the effect of coherent scattering appeared clearly. The factors influencing the thermalization parameters which are important in pile physics became evident, especially for small systems. (auth) (NSA of Japan)

16315 THE DEVELOPMENT AND APPLICATION OF A MONTE CARLO METHOD FOR REACTOR SAFETY AND RELIABILITY ANALYSIS. Brunot, William Kennedy. College Park, Md.; Univ. of Maryland (1969). 125p.

Thesis.

A method for determining the probabilities of accidents and other reactor system occurrences has been developed and used successfully on several subsystems. The method consists of constructing a digital model of the many possible components and events in a system, and operating the model to produce a time history of the system. The events are allowed to occur as they would in the real system, and the desired probabilities are determined by counting the number of occurrences. The method bears some resemblance to the Monte Carlo approach used in particle transport problems. Compared to standard reliability analysis techniques, large savings in computer time have been achieved in some classes of problems. In addition, problems impractically complex for standard methods have been solved without difficulty. The program can be used to determine the total probabilities of dependent events, chains, and subsets; to identify and compare the relative importance of chains and causes; and to determine the types and quantities of data required from a real system to achieve a given accuracy. (Diss. Abstr.)

## Reactor Components, Fuels, and Accessories

*Refer also to abstracts 13866, 13997, 14123, 14129, 14135, 14144, 14163, 14207, 14212, 14639, 14640, 14642, 14658, 14665, 14666, 14668, 14671, 14674, 14681, 14688, 14692, 14694, 14697, 14698, 14708, 14794, 14808, 14811, 14834, 14843, 14854, 14866, 14867, 14878, 14892, 14893, 14918, 14964-14966, 14970, 14975, 14976, 14978, 14987, and 14988.*

16316 (ARH-600(Vol.2)) CRITICALITY HANDBOOK. VOLUME II. Carter, R. D.; Kiel, G. R.; Ridgway, K. R. (Atlantic Richfield Hanford Co., Richland, Wash.). 23 May 1969. Contract AT(45-1)-2130. 154p. Dep. CFSTI.

Because of the increase in data presented, the Criticality Handbook has been issued as two volumes. Volume I includes administrative criteria, engineering data, and Part A of parameters of homogeneous systems. Volume II includes Parts B, C, and D of homogeneous systems parameters, interaction data, and data on poisoned systems. Loose-leaf pages containing additions and modifications of Volume I data are included with the Volume II publication. (H.D.R.)

16317 (BNWL-1289) PLUTONIUM UTILIZATION PROGRAM. Technical Activities Quarterly Report, September-November 1969. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 74p. Dep. CFSTI.

PLUTONIUM OXIDES $PuO_2$—$PuO_2$–$UO_2$, reaction rates in fuels of, effects of particle size on relative, (E/T)
—$PuO_2$–$UO_2$, irradiation performance of PRTR fuels of, (E)
—$PuO_2$–$UO_2$, irradiation testing of defected fuels of, power generation and heat transfer calculations for
PLUTONIUM RECYCLE TEST REACTOR—fuel element clusters in, effects of one and two dimensional lattice cell representations on physics parameters of, (T)
—fuel elements for, irradiation performance of mixed oxide, (E)
—deactivation of
REACTOR FUEL ELEMENTS—reaction rates in plutonium oxide ($PuO_2$)–uranium oxide ($UO_2$), effects of fuel particle size on relative, (E/T)

—performance of PRTR mixed oxide, postirradiation evaluation of, (E)
REACTOR FUELS—radiation testing of defected mixed oxide, power generation and heat transfer calculations for
—transient testing of mixed oxide, capsule calibration for
URANIUM OXIDES $UO_2$—$PuO_2$–$UO_2$, reaction rates in fuels of, effects of particle size on relative, (E/T)
—$PuO_2$–$UO_2$, irradiation performance of PRTR fuels of, (E)
—$PuO_2$–$UO_2$, irradiation testing of defected fuels of, power generation and heat transfer calculations for (H.D.R.)

**16318** (EUR-4280(Vol.1)) INFORMATION MEETING ON WORK RELATING TO PRESTRESSED CONCRETE VESSELS AND THEIR ISOLATION, BRUSSELS, 7–8 NOVEMBER 1967. (European Communities, Luxembourg. Commission). 1969. 416p. (In several languages). (CONF-671145-(Vol.1)).

Work carried out in the Euratom Community on the development of prestressed concrete reactor vessels is detailed. Sessions of the conference include: the basic research on concrete technology and containers under temperature and radiation loadings; new pressure vessel prototype designs; research and development for prestressed concrete pressure vessels; and insulation and heat transfer within the vessels. Separate abstracts are prepared for each of the 15 separate papers. (M.L.S.)

*For abstracts of individual papers see: 14123, 14871, 14989–14993, 16179–16182, and 16319–16322.*

**16319** (EUR-4280(Vol.1), pp 157-86) NEW PRESTRESSING PROCEDURES APPLICABLE TO REACTOR PRESSURE VESSELS. Patin, P. (Regie Autonome des Transports Parisiens (France)); Loca, R.; Noel, G. (In French).

A new prestressing procedure, which is proposed for use with reactor pressure vessels, is described; the prestressing steps are delineated. Post-prestressing testing is discussed. The research and development efforts which are needed for further development of the procedure are described. (M.L.S.)

**16320** (EUR-4280(Vol.1), pp 187-222) BRIEF RESULTS OF MEASUREMENTS [ON THE PRESTRESSING OF REACTOR VESSELS]. Noel, Georges (Centre Experimental de Recherches et d'Etudes du Batiment et des Travaux Publics, Paris (France)). (In French).

Results of theoretical and experimental studies on a $\frac{1}{10}$-scale model of an externally prestressed pressure vessel are presented. Apparatus used for the extensometric and thermal measurements are described in detail for a liquid and a solid prestressing process. Data are shown graphically. (J.S.R.)

**16321** (EUR-4280(Vol.1), pp 289-303) PRESTRESSED PRESSURE VESSELS AND THERMAL INSULATION FOR WATER COOLED REACTORS. Gruhl, H. (Siemens A.G., Erlangen (West Germany)). (In German).

A 1:4 scale model of a pressure vessel for 100 atm internal pressure and 10 m internal diameter was built to test the construction techniques and to determine the integrity of the scale model. The construction techniques are outlined and illustrated. The research program for the model-vessels is outlined. This research includes work in the areas of: concrete, prestressed steel, and insulation material; pressure and temperature loadings for the vessel; and investigations into vessel ruptures. (M.L.S.)

**16322** (EUR-4280(Vol.1), pp 355-92) PRESTRESSED CONCRETE PRESSURE VESSEL FOR NUCLEAR REACTORS EXPERIMENTS ON SMALL MODELS. Torielli, E.; Scotto, F. (Ente Nazionale per l'Energia Elettrica, Rome (Italy)).

The state of the technology of prestressed concrete reactor vessel (PCRV) design is discussed. The scale models of the PCRV which are being used for perfecting construction and testing techniques are described; model materials are discussed. Results of testing are described; data are shown graphically. Costs of the mockup tests are outlined. (M.L.S.)

**16323** (EUR-4400) THERMAL INSULATION OF A REACTOR PRESSURE TUBE BY INTERNAL COATING WITH SPRAYED ZIRCONIUM OXIDE. Henry, B.; Simonet, R. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 4 Aug 1969. 58p. (In French). Dep. CFSTI (U. S. Sales Only). EUR.

The fabrication problems connected with the cooling channel of a nuclear reactor, consisting of a Zircaloy-2 cold pressure tube, inside coated with sprayed zirconium oxide, are examined. The mechanical strength of the insulating coating and thermal losses are analyzed. Fabrication of a full-scale test model is described. 14 references. (auth)

**16324** (TRG-Report-1927) REFUELLING THE EARLY U. K. REACTORS. Dent, K. H. (United Kingdom Atomic Energy Authority, Risley (England). Reactor Group); Robertson, W. B. (United Kingdom Atomic Energy Authority, Sellafield (England). Reactor Group). 1969. 22p. Dep. CFSTI (U. S. Sales Only).

Britain's first reactor, GLEEP, had no refuelling equipment and its first charge of fuel was not expected to be replaced. It was eventually refuelled by hand and twenty-one years later is still in operation. The BEPO reactor and the two air-cooled production reactors at Windscale were designed to be refuelled; even so, the operators found it easier to charge and discharge the channels by hand than to use machines provided for the purpose. With the vertical $CO_2$-cooled reactors of Calder Hall, fuel handling equipment became essential but its success owed much to its simplicity born of previous experience. 4 references. (auth) (UK)

**16325** ROSSI-$\alpha$ TIME CORRELATOR. Nargundkar, V. R.; Subbarao, K.; Eligar, S. K.; Joshi, B. V. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., Bombay, 1968; 2: 376-81(1968).

From Nuclear Physics and Solid State Physics Symposium, Bombay, India. See CONF-681210-(Vol.2).

Design parameters are presented for a Rossi-$\alpha$ time correlator using magnetic-core-transistor-switching circuits. 3 references. (D.C.C.)

**16326** NUCLEAR REACTOR THERMOMETRY. (to Panametrics Inc.). British Patent 1,178,529. 21 Jan 1970. Priority date 18 Mar 1968, United States.

REACTORS, BREEDER—core for, ultrasonic transmission system for temperature measurements in
REACTORS, FAST—core for, ultrasonic transmission system for temperature measurements in
REACTORS, LIQUID METAL COOLED—core for, ultrasonic transmission system for temperature measurements in
THERMOMETRY—transmission of measurements in liquid metal cooled reactor, use of ultrasonics for
ULTRASOUND—use for transmission of temperature measurements, in liquid metal cooled reactors (H.D.R.)

**16327** RADIATION SHIELDING AND COOLING FOR NUCLEAR REACTOR UTILIZING MOLTEN METAL. Parker, Horace Frank; Webb, John (to United Kingdom Atomic Energy Authority). U. S. Patent 3,493,758. 3 Feb 1970. Priority date 11 May 1965, Great Britain.

Radiation shielding, suitable for use in nuclear reactor environments, in which one face of the shielding is exposed to a hotter environment than another face, has such faces consititued by hollow walls which are filled by a metal which remains molten in service. The hollow interiors of the hollow walls are interconnected to permit a natural convection, closed circulation of the molten metal for reducing the temperature differential of the faces. The shielding can have penetrations. (Offic. Gaz.)

**16328** ASSESSMENT OF AIR FILTERS AT ELEVATED TEMPERATURES AND PRESSURES. Dyment, J. (Atomic Weapon Research Establishment, Aldermaston, Eng.). pp 58-61 of Choosing the Right Equipment for Dust Control and Air Cleaning. Croydon, Eng.; Filtration Society (1969).

From Conference on Choosing the Right Equipment for Dust Control and Air Cleaning, London, England. See CONF-690935.

The need for practical information on the performance of high efficiency filter units in conditions of elevated temperature and pressure with special reference to filters for the nuclear energy industry is stated. The restricted life of these filters at high temperatures due to leakage induced by thermal cycling is noted. Test procedures, both those in which the units are exposed to the hostile environment and then checked for integrity under normal conditions (static oven tests and flow tests) and also those carried out while operating at elevated temperature and/or pressure, are described. (UK)

**16329** DOOR APPARATUS FOR PRESSURE-TIGHT AND GAS-TIGHT LOCK. (to Licentia Patent-Verwaltungs GmbH). British Patent 1,181,108. 11 Feb 1970. Priority date 22 Mar 1966, Germany.

AIR LOCKS—door for pressure tight and gas tight, with means for fast opening in emergency
DOORS—design of counter weighted and hydraulic motor driven, for use with reactor containment air locks
REACTOR CONTAINMENT STRUCTURES—air locks for, hydraulic motor driven door with counter weights for (H.D.R.)

**16330** GERMAN IMPORT AND EXPORT OF NUCLEAR FUELS IN 1968. Atomwirt., Atomtech.; 14: 585(Dec 1969). German).

**16331** MECHANICAL DEVICE FOR QUICKLY DISCONNECTING DRIVE MECHANISM FROM CONTROL ROD OF NUCLEAR REACTOR. Zinn, Walter H. (to Combustion Engineering, Inc.). U. S. Patent 3,494,827. 10 Feb 1970. Filed 10 Oct 1967.

An apparatus for connecting, driving and disconnecting the control rods in a nuclear reactor employing a drive mechanism of the rack and pinion type is described. The motor and drive shaft that operate the pinion are eccentrically mounted on the apparatus housing in parallel but nonaligned relation to the axis of the rack. An access tube which communicates with the housing interior is mounted on the housing cover in axial alignment with the rack and the nut assembly that connects the rack to the control rod coupler assembly thereby facilitating disconnection of the control rod from the drive mechanism in order that the latter can be removed from the reactor vessel together with the mechanism housing in one operation. (Offic. Gaz.)

16332 NUCLEAR REACTOR DIRECT PRESSURE SUPPRESSION CONTAINMENT. Chave, Charles T. (to Stone and Webster Engineering Corp.). U. S. Patent 3,494,828. 10 Feb. 1970. Filed 18 Dec 1967.

Direct pressure suppression in a nuclear reactor containment structure is achieved by providing a liquid reservoir of predetermined volume and specific gravity established at a point which is less than that of water so that steam condensing at the surface will sink into the reservoir. The sinking condensate causes circulation within the reservoir, enabling the reservoir to continually absorb steam until thermal equilibrium is reached. The liquid reservoir is preferably comprised of water diluted with either a fluid or particulate solid material so as to be in the form of either a solution, emulsion or solid-water suspension. Also preferably, the fluid additive material is selected so as to have a low vapor pressure to minimize the amount of vaporization generated upon steam condensation. (Offic. Gaz.)

# GENERAL

**16333** (AEC-tr-6931/4-5) NUKLEONIKA. Translation of Nukleonika; 13: No. 4-5, 361-590(1968). 224p. (TT-68-50011/4-5). Dep. CFSTI.

**16334** (AEC-tr-6931/8) NUKLEONIKA. Translation of Nukleonika; 13: No. 8, 827-952(1968). 120p. (TT-68-50011/8). Dep. CFSTI.

**16335** (ANL-7631) HARTREE–FOCK SELF-CONSISTENT FIELD CALCULATIONS FOR IRIDIUM. Panek, L. W.; Perlow, G. J. (Argonne National Lab., Ill.). Nov 1969. Contract W-31-109-eng-38. 42p. Dep. CFSTI.

**16336** (BDX-613-128) LEAD WIRE SOLDERABILITY TEST. Turner, W. W. (Bendix Corp., Kansas City, Mo.). [nd]. 8p. Dep. CFSTI.

**16337** (BDX-613-129) DEVELOPMENT OF INSTRUMENTATION FOR RELIABLE PERCUSSIVE ARC WELDING SYSTEMS. Patterson, I. V. (Bendix Corp., Kansas City, Mo.). [1969]. 11p. (CONF-700104-1). Dep. CFSTI.
From Instrument Society of America Symposium, Albuquerque, N. Mex.

**16338** (BNL-14337) USERS MANUAL FOR GENASY: AN OFF-LINE ASSEMBLER FOR THE VARIAN 620/i COMPUTER. Greenlaw, N. E.; McGuire, E. L.; Weingart, S. W. (Brookhaven National Lab., Upton, N. Y.). Dec 1969. 54p. Dep. CFSTI.

**16339** (BNL-tr-313) PARTIAL DERIVATIVE EQUATIONS OF MATHEMATICAL PHYSICS. Poincare, H. Translated for Brookhaven National Lab., Upton, N. Y., from Amer. J. Math.; 12: 28-294(1890). 100p. Dep. CFSTI.

**16340** (BNWL-1277) SIMULATION MODELING OF THERMAL EFFLUENT IN AN IRRIGATION SYSTEM. Peterson, D. E.; Jaske, R. T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 33p. Dep. CFSTI.

**16341** (COO-623-149) MOESSBAUER EFFECT OF ULTRA THIN IRON FILMS. Technical Report No. 62. Zuppero, Anthony Charles (Case-Western Reserve Univ., Cleveland, Ohio, Dept. of Physics). Jan 1970. Contract AT(11-1)-623. 64p. Dep. CFSTI.

**16342** (COO-716-54) VAPORIZATION THERMODYNAMICS OF EUROPIUM DIBROMIDE. Haschke, John M.; Eick, Harry A. (Michigan State Univ., East Lansing. Dept. of Chemistry). [1969]. 12p. Dep. CFSTI.
The congruent vaporization of condensed europium dibromide to the gaseous molecule was studied over the temperature range 1185 to 1568°K by a target collection Knudsen effusion technique. For the reaction at 1377, $\Delta H^0_T = 58.2_7 \pm 0.7_6$ kcal/gfw and $\Delta S^0_T = 23.0_3 \pm 0.5_6$ eu. Calculations employing estimated heat capacities yield $\Delta H^0_{298} = 71._4 \pm 2._7$ kcal/gfw, $\Delta S^0_{298} = 36._8 \pm 2._3$ eu and for $EuBr_2$ (s) $S^0_{298} = 39._4 \pm 3._6$ eu. Enthalpies and free energies of formation calculated for condensed and gaseous dibromide are presented and discussed. (auth)

**16343** (COO-890-11) PREPARATION OF $^{14}C$ AND TRITIUM LABELED COMPOUNDS BY HYDROBORATION AND TRITIOBORATION PROCEDURES. Technical Progress Report, May 1, 1969–April 30, 1970. (Illinois Univ., Urbana). Contract AT(11-1)-890. 9p. Dep. CFSTI.

**16344** (COO-1018-1194) ILLIAC III COMPUTER SYSTEM MANUAL: ARITHMETIC UNITS. VOLUME I. Report No. 366. Atkins, Daniel E. (Illinois Univ., Urbana. Dept. of Computer Science). Dec 1969. Contract AT(11-1)-1018. 242p. Dep. CFSTI.

**16345** (COO-1018-1195) GRAPH TRANSFORMATIONS FOR COMPOSITE FORMATION. Report No. 368. Schwebel, John C. (Illinois Univ., Urbana. Dept. of Computer Science). 12 Dec 1969. Contract AT(11-1)-1018. 26p. Dep. CFSTI.

**16346** (COO-1198-701) MOESSBAUER STUDY OF THE TEMPERING OF MARTENSITE. Rarey, Charles Russell (Illinois Univ., Urbana). Feb 1970. Contract AT(11-1)-1198. 58p. Dep. CFSTI.

**16347** (COO-1269-21) SOIL WATER REDISTRIBUTION DURING EVAPORATION. Fritton, Daniel Dale (Iowa State Univ. of Science and Technology, Ames). 1968. Contract AT(11-1)-1269. 154p. Dep. CFSTI.

**16348** (COO-1285-15) PREVENTION OF INTERACTIONS BETWEEN ERYTHROCYTE SURFACE STRUCTURES AND BLOOD-GROUP RELATED TOXIC SUBSTANCES OF MICROBES. Progress Report, February 1969–February 1970. Springer, Georg F. (Northwestern Univ., Evanston, Ill.). Contract AT(11-1)-1285. 9p. Dep. CFSTI.

**16349** (COO-1385-28) NUCLEAR QUADRUPOLE RESONANCE ZEEMAN STUDIES OF p-BROMOBENZENESULFONYL CHLORIDE AND p-BROMOANILINE HYDROCHLORIDE. Rao, K. V. S. Rama; Rogers, Max T. (Michigan State Univ., East Lansing. Dept. of Chemistry). [1969]. 14p. Dep. CFSTI.

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Thesis.

**16352** (COO-1599-25(Pt.1)) DISSOLVED ORGANIC MATTER AND LAKE METABOLISM. Technical Progress Report, April 15, 1969–January 15, 1970. Wetzel, Robert G. (Michigan State Univ., East Lansing). 15 Jan 1970. Contract AT(11-1)-1599. 25p. Dep. CFSTI.

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**16357** (COO-2039-3) ELECTRONIC SPECTRA AND STRUCTURE OF SCHIFF BASES. I. BENZANILS. El-Bayoumi, M. Ashraf; El-Aasser, M.; Abdel-Halim, F. (Alexandria Univ. (Egypt), Michigan State Univ., East Lansing. Dept. of Biophysics). [1968]. Contract AT(11-1)-2039. 21p. Dep. CFSTI.

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16362 (IS-2243) INTERPRETIVE LANGUAGE WITH AN ASSOCIATED DATA STRUCTURE. Zamecnik, Fred John Jr. (Ames Lab., Iowa). Jan 1970. Contract W-7405-eng-82. 99p. Dep. CFSTI.
Thesis.

The theory and implementation of a programming language called AMP which is a simulation of an associative memory structure is described. The language consists of a structured memory base imbedded in an interpretive language processor which has powerful recursive properties. The affected areas, the language structure, the storage technique, the program implementation, and the possible extensions are described. This particular implementation was written for an IBM 360/65. (auth)

16363 (IS-T-325) OPTICAL PROPERTIES OF SILVER-PALLADIUM ALLOYS. Schmidt, Bruno Francis (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 107p. Dep. CFSTI.
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16364 (IS-T-326) SINGLE CRYSTAL SUSCEPTIBILITY STUDY OF ONE-DIMENSIONAL ANTIFERROMAGNETIC INTERACTIONS IN $CsCuCl_3$. Rioux III, Frank Joseph (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 97p. Dep. CFSTI.
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16365 (IS-T-327) OPTICAL PROPERTIES OF CHROMIUM-MANGANESE ALLOYS. Bos, Laurence William (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 92p. Dep. CFSTI.
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16366 (IS-T-347) LOW TEMPERATURE, MATRIX ISOLATION, PHOTOCHEMISTRY: REACTIONS OF SULFUR ATOMS. Davis, Mark Noble (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 44p. Dep. CFSTI.
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16367 (K-Trans-55) THEORETICAL STUDIES ON THE INFLUENCE OF WALL FRICTION ON THREE-DIMENSIONAL FLOW IN AXIAL TURBOMACHINERY. Keusenhoff, Juergen. Translated for Oak Ridge Gaseous Diffusion Plant, Tenn., from German Thesis. 122p. Dep. CFSTI.

16368 (LA-4144-tr) PHYSICAL PRINCIPLES OF PRACTICAL LIQUID RESISTORS FOR PULSE VOLTAGES. Mosch, W. Translated for Los Alamos Scientific Lab., N. Mex., from Deut. Elektrotech.; 9: 214-18(1955). 9p. Dep. CFSTI.

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16372 (NYO-2798-48) EVIDENCE FOR $n_C \rightarrow \pi^*$ TRANSITION IN N-MALONIC ESTERS OF HETEROCYCLIC COMPOUNDS. Nnadi, John C.; Wang, Shih Yi (Johns Hopkins Univ., Baltimore, Md. Dept. of Biochemistry). [1969]. 21p. Dep. CFSTI.

16373 (NYO-2798-51) CRYSTAL STRUCTURES OF DIMERS OF URACIL AND 6-METHYLURACIL. Konnert, John; Gibson, John W.; Karle, Isabella L.; Khattak, M. N.; Wang, S. Y. (Johns Hopkins Univ., Baltimore, Md. School of Hygiene and Public Health). [1969]. 12p. Dep. CFSTI.

16374 (NYO-3829-46) COMPLETE CONTINUITY OF THE INVERSE OF THE LAPLACIAN AND GREEN'S FUNCTION. Fink, James P. (Pittsburgh Univ., Pa.). Jan 1970. Contract AT(30-1)-3829. 16p. Dep. CFSTI.

The theory of strictly positive definite operators and completely continuous symmetric operators on a Hilbert space is applied to certain boundary value problems in mathematical physics. The application to the eigenvalue problem for the vibrating membrane is discussed in detail. (auth)

16375 (ORNL-4484) MIDDLE EAST STUDY: MARKETS AND POTENTIALS FOR AGRICULTURAL OUTPUT OF A MIDDLE-EAST AGRO-INDUSTRIAL COMPLEX. (Little (Arthur D.) Inc., Cambridge, Mass.). Feb 1970. Contract W-7405-eng-26. 82p. Dep. CFSTI.
For Oak Ridge National Lab., Tenn.

16376 (ORNL-4527) ADEQUATE SAMPLE SIZES FOR RANDOMIZED BLOCK DESIGNS. Kastenbaum, Marvin A.; Hoel, David G.; Bowman, K. O. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 48p. Dep. CFSTI.

Techniques described in an earlier report are used to generate tables of sample size requirements for testing treatment effects in a randomized block design. Maximum values of the standardized range of the treatment means are tabulated for k = 2(1)6 treatments; b = 2(1)5 blocks; N = 1(1) 30(2) 50(5) 100 observations per cell; and $\alpha$ = 0.01, 0.05 and $\beta$ = 0.005, 0.01, 0.025, 0.05, 0.1, 0.2, 0.3, 0.4 levels of risk. (auth)

16377 (ORNL-TM-2622) OPTICAL CONSTANTS OF CESIUM FOR PHOTONS OF ENERGY 5 TO 9.6 eV. Whang, U. S.; Callcott, T. A.; Arakawa, E. T. (Oak Ridge National Lab., Tenn.). Mar 1970. Contract W-7405-eng-26. 79p. Dep. CFSTI.
Thesis. Submitted by U. S. Whang to Univ. of Tennessee, Knoxville.

16378 (ORNL-TM-2794) CONSTRUCTION AND USE OF A HIGH RESOLUTION PHOTOELECTRON SPECTROMETER. Pullen, Bailey Price (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 129p. Dep. CFSTI.
Thesis. Submitted to Univ. of Tennessee, Knoxville.

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16380 (ORNL-tr-2269) PRINCIPAL HYDRAULIC JET PARAMETERS AND STRESS DISTRIBUTION IN COAL SEAMS DURING HYDRAULIC CRUSHING. Hokao, Zenjiro. Translated for Oak Ridge National Lab., Tenn., from Nippon Kogyo Kaishi; 81: No. 930, 23-8(1965). 13p. Dep. CFSTI.

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16383 (ORNL-tr-2272) MAIN TRENDS OF RADICALLY IMPROVING THE MAIN WATER DRAINAGE OF MINES. Geier, V. G.; Malygin, S. S. Translated for Oak Ridge National Lab., Tenn., from Ugol; 40: No. 7, 41-6(1965). 9p. Dep. CFSTI.

16384 (ORNL-tr-2281) USE OF RADIOTRACERS IN THE STUDY OF THE EFFECT OF SILICON ON VARIOUS PROPERTIES OF THE GRAIN BOUNDARIES OF AUSTENITIC STAINLESS STEELS. Desestret, A.; Froment, M.; Guiraldenq, P. Translated by R. Gregg Mansfield (Oak Ridge National Lab., Tenn.), from Mem. Sci. Rev. Met.; 66: 389-405(1969). 31p. Dep. CFSTI.

16385 (ORO-2575-45) CYTOCHEMISTRY OF MATERIAL ASSOCIATED WITH NUCLEAR PORES IN OOCYTES OF RANA PIPIENS LARVAE. Cole, Madison Brooks Jr. (Tennessee Univ., Knoxville). Mar 1969. 66p. Dep. CFSTI.
Thesis.

16386 (ORO-3935-3) STUDY OF ALLOY STRENGTHENING DUE TO ATOMIC ORDER. Progress Report, May 1, 1969–April 30, 1970. Marcinkowski, M. J. (Maryland Univ., College Park). Contract AT(40-1)-3935. 47p. Dep. CFSTI.

16387 (RIAS-3706-15) PHOTOCHEMISTRY AND ENZYMOLOGY OF PHOTOSYNTHESIS. Period Covered: May 1, 1969–January 30, 1970. (Martin Marietta Corp., Baltimore, Md. Research Inst. for Advanced Studies). Contract AT(30-1)-3706. 13p. Dep. CFSTI.

16388 (SC-DR-69-840) CONVIP: A PROGRAM LINKING SWAP-9 TO WONDY-3. Lundergan, C. D. (Sandia Labs., Albuquerque, N. Mex.). Dec 1969. 45p. Dep. CFSTI.

The computer program, CONVIP, transfers a problem which has been run by the WONDY-3 program up to a predetermined time into the SWAP-9 program for completion of the problem. For a certain class of one-dimensional rectilinear wave propagation problems this procedure substantially reduced the computer time required to obtain a solution. The class of problems consists of those in which large regions of the medium are in uni-

form motion, have time-dependent energy deposition or boundary conditions, require many meshes for an adequate description in the WONDY-3 program, and require several microseconds for solution. (auth)

**16389** (SC-DR-69-843) STRAIN GAGE AND ACCELEROMETER TESTING. Dain, F. C. (Sandia Labs., Albuquerque, N. Mex.). Jan 1970. 6p. Dep. CFSTI.

A simple, inexpensive method of actuating tuning forks used in the dynamic testing of strain gages and accelerometers is presented. This technique is particularly useful for pretesting of the instrumented tuning forks. (auth)

**16390** (SC-M-69-337) A GUIDE TO THE SANDIA MATHEMATICAL PROGRAM LIBRARY. Bailey, C. B. (Sandia Labs., Albuquerque, N. Mex.). Jan 1970. 89p. Dep. CFSTI.

**16391** (SC-M-69-602) PROGRAM DOCUMENTATION FOR ACCEL MOD 2. Fisk, Clifford J.; Caskey, David L. (Sandia Labs., Albuquerque, N. Mex.). Dec 1969. 264p. Dep. CFSTI.

**16392** (SC-M-70-3) DEVELOPMENTS IN TECHNIQUES FOR COMPUTATION OF BESSEL FUNCTIONS BY DIGITAL COMPUTERS. Halbgewachs, R. D. (Sandia Labs., Albuquerque, N. Mex.). Feb 1970. 44p. Dep. CFSTI.

**16393** (SC-RR-70-53) PIEZOELECTRIC FIELD EFFECT STRAIN GAUGE. Crawford, J. C. (Sandia Labs., Albuquerque, N. Mex.). Jan 1970. 43p. Dep. CFSTI.

**16394** (SC-T-70-4006) CONCERNING THE STRUCTURE OF PRECIPITATIONS. III. RAIN IN THE ARCTIC, TEMPERATE, AND TROPICAL ZONES. Diem, M. Translated by Marcel I. Weinreich (Sandia Labs., Albuquerque, N. Mex.), from Arch. Meteorol., Geophys. Bioklimatol., Ser. B; 16: 347-90(1968). 45p. Dep. CFSTI.

**16395** (SC-T-70-4007) ANGULAR DISTRIBUTION OF A SUBSTANCE HAVING BEEN VAPORIZED BY A LASER BEAM. Bykovskii, Yu. A.; Dudoladov, A. G.; Degtiarenko, N. N.; Elesin, V. F.; Kozyrev, Yu. P.; Nikolaev, I. N. Translated by Marcel I. Weinreich (Sandia Labs., Albuquerque, N. Mex.), from Zh. Eksp. Teor. Fiz.; 56: 1819-22(1969). 6p. Dep. CFSTI.

**16396** (SCL-DR-69-165) SEPARATING LARGE THIN ELECTROFORMED PARTS FROM MANDRELS. Dini, J. W.; Johnson, H. R. (Sandia Labs., Livermore, Calif.). Feb 1970. Contract AT(29-1)-789. 19p. Dep. CFSTI.

**16397** (STI/DOC-11(Vol.7)(No.3)) LIST OF BIBLIOGRAPHIES ON NUCLEAR ENERGY. (International Atomic Energy Agency, Vienna (Austria)). [1969]. 31p. Dep. IAEA.

A list of 151 bibliographies (published or in preparation) on nuclear energy is presented. An author index and a corporate author index are included. (W.H.K.)

**16398** (TID-25346) STRUCTURAL RELAXATION IN LIQUIDS. Progress Report No. 9. Litovitz, T. A. (Catholic Univ. of America, Washington, D. C.). Feb 1970. Contract AT(40-1)-2854. 5p. Dep. CFSTI.

**16399** (TID-25347) COLLABORATION BETWEEN INFORMATION ANALYSIS CENTERS AT A LARGE, MULTIPURPOSE LABORATORY. Kertesz, Francois (Oak Ridge National Lab., Tenn.). [1969]. 16p. (SM-128/29). Dep. CFSTI.

The interaction and collaboration of a group of information centers located at the same large multipurpose institution are discussed, and the information centers at Oak Ridge National Laboratory are described as an example. (W.H.K.)

**16400** (UCLA-12-762) EFFECTS OF CORTISOL AND EPINEPHRINE ON GLIAL CELLS IN CULTURE. de Vellis, J.; Inglish, D.; Galey, F. (California Univ., Los Angeles. Lab. of Nuclear Medicine and Radiation Biology). [1969]. Contract AT-04-1-GEN-12. 19p. Dep. CFSTI.

**16401** (UCLA-12-763) FATTY ACID UPTAKE BY THE BRAIN. III. INCORPORATION OF OLEIC ACID 1-$^{14}$C INTO THE ADULT RAT BRAIN. Dhopeshwarkar, G. A.; Mead, James F. (California Univ., Los Angeles. Lab. of Nuclear Medicine and Radiation Biology). [1969]. Contract AT-04-1-GEN-12. 16p. Dep. CFSTI.

**16402** (UCRL-19403) SMOOTHING DATA WITH TOLERANCES BY USE OF LINEAR PROGRAMMING. Young, Jonathan D. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 6p. Dep. CFSTI.

A method for smoothing observed data when the values of the dependent variable are assumed to lie within specified tolerance of the observed value is described. Linear programming is employed to obtain optimal smoothing of the (local) degree desired within the restraints imposed by the tolerances. First- and third-degree smoothing are discussed, but the method may be extended to higher order. (auth)

**16403** (UCRL-50694) FOURTH PROGRESS REPORT OF LIGHT ARMOR PROGRAM. Wilkins, M. L.; Cline, C. F.; Honodel, C. A. (California Univ., Livermore. Lawrence Radiation Lab.). 4 Jun 1969. 62p. Dep. CFSTI.

**16404** (UCRL-71927(Rev.)) CONTROL OF MULTIPLE-HEAD SHAKER SYSTEMS: AN APPLICATION OF LINEAR ALGEBRA. Wyman, R. H. (California Univ., Livermore. Lawrence Radiation Lab.). 15 Jan 1970. 6p. (CONF-700402-1). Dep. CFSTI.

From 16th Annual Meeting and Equipment Exposition, Boston, Mass.

**16405** (UCRL-Trans-10387) TRIMETHYLOLAMINOMETHANE IN MANNICH REACTIONS. Nesterenko, D. A.; Savchenko, O. M.; Eremenko, L. T. Translated by A. M. A. Mincer for Univ. of California Lawrence Radiation Lab., Livermore, from Russian Preprint. 15p. Dep. CFSTI.

**16406** (UCRL-Trans-10433) PLUTO AND TRANS-PLUTO. Strubell, W. Translated by J. Hawke for Univ. of California Lawrence Radiation Lab., Livermore, from Sterne; 29: No. 5-6, 111-13(1953). 8p. Dep. CFSTI.

**16407** (YALE-3227-62) MAGNETIC SUSCEPTIBILITY MEASUREMENTS WITH A TUNNEL DIODE OSCILLATOR. Clover, R. B.; Wolf, W. P. (Yale Univ., New Haven, Conn. Hammond Lab.). [1969]. 25p. Dep. CFSTI.